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THE UNIVERSITY OF ALBERTA

DEVELOPMENT AND VALIDATION OF A FORM-FUNCTION TEST OF PREFERENCE FOR COGNITIVE PROCESSING STRATEGIES

BY

JEAN DAVIDSON KUIJT

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA
SPRING, 1986

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TO

JOB and CAROL

ABSTRACT

The study was designed to develop an instrument for measuring preferences for cognitive processing strategies in children. Of special interest were strategies characteristic of each hemisphere, namely: **Verbal-Analytic (V-A)** for the left (linguistic thinking and categorizing using common class membership), and **Spatial-Holistic (S-H)** for the right (the ability to use template-matching for visual stimuli). The test assesses one facet of the differences found to be associated with V-A and S-H processing: a preference for matching simple line-drawings according to their **Function** (V-A) or **Form** (S-H).

A three factor fixed effects design was used with the sample stratified to include children at five levels of Age (5, 6, 7, 9, and 11), three Cognitive Processing Balance Groups (using Wechsler Vocabulary + Similarities versus Block Design + Object Assembly), and two levels of Reading Achievement.

In the F-F Preference Test, the subject interprets the **ambiguous** instructions to imply either a search for visual similarity or functional association. Loevinger's (1957) model for test development was used with the final version of the test consisting of 16 Form/Function items. The test proved internally consistent and showed adequate test-retest reliability.

Analyses of Variance of F-F Test scores showed a significant effect of Age and a significant interaction between Age and Reading Achievement. The hypothesized effect of Cognitive Processing Balance on F-F Test scores was not confirmed by the data. The effect of Age was quadratic with 5 year olds choosing 50% Form, 6-9 year olds, 75% Form, and 11's choosing 50% Form. At age 11 Poor Readers made significantly more Form choices than did Good Readers. Factor analyses indicated that 5 year olds did not regard the test items as a simple choice between Form and

Function. Factor patterns for the Cognitive Balance Groups differed with structural validity being supported by the results for the V-A Group but not the S-H and Equal Groups.

While the F-F Preference Test has no validity as an instrument for distinguishing between the three Cognitive Balance Groups in children up to age 11, the test is a valid indicator of differences in preference for Form or Function at different ages. By age 11, Poor Readers lag significantly behind Good Readers in making a transition from Form to Function choices. Trends indicate that the F-F Preference Test may be valid in showing differences among the Balance groups within the Age and Reading groups, especially at ages 5 and 11.

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1. INTRODUCTION

> Nancy, at the age of five, got along very well at her day care centre seeming to be about as mature as the other children. She loved to draw and to climb on the jungle gym but rarely sat still to look at books. She had trouble adjusting to the grade one program, however, and barely passed. In grade two, she found it extremely difficult to copy from the blackboard, was slow in doing her work, and was finally sent to the resource room for special help. She did well as long as the teacher was working with her but tended to daydream instead of taking responsibility for her tasks. The teacher complained that all Nancy wanted to do was draw.
>
> In grade five, Nancy had the greatest difficulty understanding the three levels of government in Canada. She tried to memorize the facts dutifully but the structure made no sense to her until her tutor drew a simple map and showed her the relationships visually. Another difficult task for her was proof-reading -- having to find errors in punctuation, capitalization, spelling, and word-use in a long list of sentences. The teacher called it a "flub-stub" test and Nancy flubbed it. She read slowly and accurately but never for pleasure -- she preferred turning cartwheels. When Nancy was scolded she could never defend herself -- in fact, she had a hard time talking at all when she was upset. Nancy didn't seem to have a learning disability; one teacher said she was "pokey" and that she didn't try hard enough. The most important point for Nancy was that she hated school for the first five years -- she just didn't seem to fit.

Excerpt from a Case Study

What causes people to have different styles of thinking and learning? What effects do these differences have on the way they approach problems? Is it possible to measure the differences and identify the extremes? What are the relationships among abilities in categorizing, analyzing, visualizing, talking, writing, copying from a blackboard, drawing and turning cartwheels? The literature reveals that these kinds of questions have been asked for a long time. Many people have assumed that their own style of thinking is the common one or even the only one. Others have been more broad-based observing many individuals and then constructing theories about how people think (Das, Kirby & Jarman, 1975; Jensen, 1970; Neisser, 1966; Paivio, 1971, Witkin, 1962).

One line of investigation in cognitive psychology has been to study the lateralization of functions to the right and left cerebral hemispheres. The left hemisphere has long been known as the "dominant" hemisphere, dominant especially for processing language in its many forms of speaking, reading, spelling and even understanding of more complex speech. Recently, the right hemisphere has been found to be more efficient for spatial processing such as remembering faces and designs, visualizing, and completing partial images. As well as being specialized for specific tasks with verbal or spatial content, the two hemispheres also seem to be differentiated in the modes of processing, the kinds of processing they do more efficiently (Bever, 1975; Bogen, 1969; Galin, 1976; Kimura, 1973; Levy, 1974; Ornstein, 1973; Sperry, 1968). The left hemisphere in general seems to be specialized for an "analytic, logical mode for which words are an excellent tool, and the right for a holistic, gestalt mode, which happens to be particularly suited for spatial relations" (Galin, 1976). Galin goes on to refer to these two modes or styles as "verbal-analytic" and "spatial-holistic", terms which will be used throughout this study to refer to the modes of processing characteristic of each hemisphere. These generalizations about the capabilities of the right and left hemispheres, however, can only be applied with any degree of certainty to right handed adult males as there seems to be considerable variation in other groups.

Several researchers have investigated individual differences in the relative efficiency with which people use the two modes of processing and also in their preferences for using them (Bogen, 1969; Bogen, DeZure, TenHouten & Marsh, 1972; Ornstein & Galin, 1974; Reynolds, 1981; Zenhausern,1978). Galin gives an example of the use of the less appropriate mode for a task: "Personally speaking, my difficulties with dancing may be related to my excessive reliance on analytic sequential processes; instead of allowing a smooth synthesis of separate parts, I have not been able to progress past counting 'one...two...THREE..., one...two...THREE'. Similarly, an excessive or inappropriate use of the holistic mode could interfere with learning to read or with carrying out sequential arithmetic calculations, such as balancing a checkbook" (Galin, 1976, p. 18). People who show a strong preference for either verbal-analytic (V-A) or spatial-holistic (S-H) processing are frequently referred to as left or right dominant or as showing hemisphericity or hemispheric preference. A common inference is that individuals who show an imbalance in their abilities on tests of the two types of processing skills will show a preference for the more efficient cognitive mode. This hypothesis has been examined with interesting but not yet clear results (Arndt & Berger, 1978; Davidson, 1980; Furst, 1976; Galin & Ornstein, 1974; Gur & Gur, 1980).

A specific example of a person with asymmetrical cognitive processing skills would be Einstein, who had severe "learning disabilities" as a child. His spatial-holistic abilities were much stronger than his verbal-analytic. His problems with speaking, reading, writing, and arithmetic apparently persisted into adult life, but his ability to use spatial-holistic processing was exceptionally good (Masland, 1976). In his autobiographical notes Einstein described the nature of his thinking; there is no doubt that his style of thinking was nonverbal and visually mediated. He thus used spatial-holistic processing in his original thinking and only later translated his ideas into algebra going through the verbal-analytic steps necessary to communicate his ideas to other scientists.

Concern has been voiced about the difficulties that some children have in school, whether they have definite learning disabilities as Einstein did or just difficulty fitting in like Nancy who was described above. A large proportion of poor readers have been found to have a cognitive processing imbalance with average or even above average spatial skills and significantly lower verbal skills (Boder, 1973; Petrauskas & Rourke, 1979). It is important that educators pay attention to the messages of psychologists like Sperry (1973) and neurologists like Geschwind (1972) who say that more importance should be attached to nonverbal forms of intellect. Our education system seems to be strongly biased toward verbal-analytic processing failing to provide much help for children like Nancy who have an imbalance with stronger Spatial-Holistic skills and weaker Verbal-Analytic skills. Even in kindergarten, children have often been given verbal-analytic strategies for learning to recognize and distinguish among different shapes, e.g. "A rectangle has four corners, two long sides and two short sides." Recently, however, much emphasis has been placed on experiential learning in kindergarten with opportunities for the children to use all their senses, especially as they are learning to read. Sesame Street helps verbal-analytically oriented children develop spatial-holistic skills and holistically oriented children make use of traditional verbal-analytic materials. Children like Nancy may need to be taught in spatial-holistic ways in order to capitalize on their strengths while overcoming their weaknesses, as was done by Nancy's tutor in presenting the structure of government in Canada to her visually. It is not clear whether a difference in **ability** to use either cognitive mode usually leads to a **preference** for the use of that type of processing or not.

Developmental psychologists have long been studying children's learning of a vast repertoire of tasks as they grow older. Individual differences in learning styles from reflective-impulsive to field dependent/independent have been examined by many researchers. Studies have also been conducted on the development of lateralization in children using various kinds of stimulation separately to each hemisphere (Bakker, 1979; Carmon, Nachshon & Starinsky, 1976; Tomlinson-Keasey, Kelly & Burton, 1978; Witelson, 1977a & b). Researchers interested in hemispheric dominance have studied the relationship between reading achievement and balance between two processing modes. While most abilities in children tend to improve with age, recently some investigators have found that some abilities such as facial-encoding actually decline around puberty before improving again till they reach an adult level (Carey, 1981).

While several authors have studied preference for one or other mode of cognitive processing, they speak of "hemispheric dominance" (Reynolds, 1981; Zenhausern, 1978), "hemisphericity" (Bogen, 1969), or "right-brained" (Gordon, 1974) implying a consistent correspondence between processing characteristic of the left (or right) hemisphere in most right-handed adult males and the exact location in an individual's left (or right) hemisphere. Since it is unwise to generalize about the specific localization of functions in a mixed group (Levy, 1981), and since cognitive skills can be measured separately from their location in the brain, it seems preferable to focus on the two modes of cognitive processing without actually attempting to infer that the processing is occurring in a subject's left or right hemisphere. Arndt & Berger (1978) warn that it is misleading to characterize individuals as being dominated by one hemisphere or the other, even though they consider that tests of cognitive mode may be adequate for characterizing the general approach and relative skill on spatial-holistic tasks compared with verbal-analytic tasks.

In this study, the development of preferences for either mode of cognitive processing will be investigated in children. Two of the best established and most accepted features of this complex association of processes characteristic of each hemisphere's specialization will be investigated, namely: verbal versus spatial and analytic versus holistic (Bradshaw, Gates & Nettleton, 1977; Galin, 1976). The single terms used here to refer to processing modes are Verbal-Analytic (V-A) and Spatial-Holistic (S-H). In this study, "Verbal-Analytic" refers to linguistic thinking, the ability to abstract attributes and categorize using common class membership; "Spatial-Holistic" refers to the ability to use template-matching or to visualize a complete object when only part is present. The purpose of this study was to construct an instrument which would examine one facet of the differences found to be associated with V-A and S-H processing: a preference for matching objects according to their Function (V-A) or Form (S-H).

Since V-A and S-H processing modes do not seem to develop at the same rate in children, a logical place to begin studying preferences for one or other mode seemed to be with young children capable of making a choice between Function and Form. In order to examine the effect of Age, Cognitive Balance and Reading Achievement on F-F Test scores, a three factor fixed effects design was used. The research sample was structured, therefore, to include children from ages 5 to 11 years, i.e. children from the end of kindergarten to the end of grade 6. Subjects were separated into Cognitive Processing Balance groups on the basis of the relative strengths of the modes of processing (Stronger V-A, Equal & Stronger S-H), and Good and Poor Reading groups on the basis of reading achievement.

This Form-Function Test of Preference for Cognitive Processing Strategies (F-F Preference Test) has importance for educators because it may provide a simple way to measure a person's preference for one of two cognitive processing modes: a choice of a Function match implying the use of Verbal-Analytic processing, a choice of Form implying Spatial-Holistic. Since the instructions are ambiguous, the subject must structure the task by interpreting the question -- **"Which picture goes together better with this one?"** -- as implying either a search for a visual similarity or a functional association. Information gained from the results of this study may provide teachers with a quick way of estimating children's Cognitive Balance through examination of their choices on the F-F Preference Test. The teachers would then be able to help children with unbalanced abilities to use their better developed strategies to learn new material more efficiently, and to develop the strategies which are less well developed building on the child's strengths in other areas. For example, Nancy's bias toward Form would indicate that she has stronger Spatial-Holistic Processing Strategies. The teachers could then help Nancy learn to use imagery as a strategy for memorizing new material. They could also give special attention to teaching her Verbal-Analytic strategies for approaching tasks like the Flub-Stub Test with which Nancy had so much difficulty.

In Chapter 2, the literature relating to lateralization of functioning of the left and right hemispheres is discussed, particularly as it relates to children and reading achievement. Chapter 3 presents the methodology pertaining to test validation with a full description of the steps which were followed in validating the F-F Preference Test. Results of the analyses of the structure of the test and the external component of validity are presented in the fourth chapter. Discussion of implications of the study and recommendations for further research are presented in the final chapter.

2. THEORY AND RELATED LITERATURE

> There are two modes of knowing, through argument and experience. Argument brings conclusions and compels us to concede them, but does not cause certainty nor remove doubts in order that the mind may remain at rest in truth, unless this be provided by experience (Roger Bacon, 1268).

Throughout the ages people have been aware of the dual nature of knowing. Some spoke of two different kinds of intelligence, Bacon wrote about two modes of knowing, and more modern psychologists speak of two different ways of information-processing. The cognitive psychologist Ulrich Neisser pointed out:

> Historically, psychology has long recognized the existence of two different forms of mental organization. The distinction has been given many names: 'rational' vs. 'intuitive', 'constrained' vs. 'creative', 'logical' vs. 'prelogical', 'realistic' vs. 'autistic', 'secondary process' vs. 'primary process'. To list them together casually may be misleading ... nevertheless, a common thread runs through all the dichotomies (Neisser, 1966, p. 297).

Neisser called one of these "sequential processing", the other "multiple processing". These terms sound quite similar to the Successive and Simultaneous Syntheses described by Das, Kirby and Jarman (1975) after Luria's model of the functions of the brain. Jensen (1970) speaks of Level I and Level II abilities, Level 1 including a pure memory factor and Level 11 characterized by "transformation and manipulation of the stimulus prior to making the response" (Jensen, 1970). Witkin (1962) has long been studying "cognitive styles" or "field articulation" in which the contrast is between Field-Independence and Field Dependence. Paivio's (1971) "dual process" theory is the basis for work by Marks (1973) and Richardson (1977) who have both designed questionnaires to discriminate between Verbalizers and Visualizers. Most of these classifications schemes seem to be based on dichotomies. Should one choose a dichotomy and, if so which one? Bogen answers the questions in this way:

> Assuming two types of intelligence, rather than some larger number, not only appeals for reasons of simplicity, but it has the very important

> advantage of conforming with the physiology of the brain. A dichotomy which has a sound physiologic basis is one which ascribes the input-output transformations to the interaction of two principal and different types of cognition, each typically identifiable with one of the two cerebral hemispheres (Bogen, 1977, p 137).

Bogen seems to be suggesting that the different styles of thinking may result from actual differences in the brain. If one wishes to investigate individual differences in cognitive processing and locations where cognitive processing goes on in the brain, then it makes sense to relate the cognitive processing models to be invesigated to neuropsychological models resulting from recent research on the brain.

HEMISPHERIC ASYMMETRY

Studies of the brain range from anatomical studies of physical differences, through direct investigation of functioning using physically invasive procedures to extremely indirect measures where functioning is inferred from reaction time or lateral eye movements. Anatomical studies of the human brain comparing the left and right hemispheres can tell us little, however, about their differential functioning. The most direct ways of investigating specialization of functions of the hemispheres have been clinical studies of neurological patients. In 1864, the British neurologist Hughlings-Jackson wrote:

> If, then, it should be proved by wider evidence that the faculty of expression resides in one hemisphere, there is no absurdity in raising the question as to whether perception -- its corresponding opposite -- may not be seated in the other (Hughlings-Jackson, 1864).

This early statement has given credence to and, in fact, has been amplified by diverse investigations into the functioning of the two hemispheres of the cerebral cortex. Functional differences in the left and right hemispheres were first noted in observing persons who had suffered brain injury to one hemisphere. Geschwind reviews the early brain research as follows:

> One of Broca's great discoveries was the observation that the form of aphasia to which his name was subsequently attached resulted from left unilateral lesions ... Wernicke ... demonstrated still further the importance of dominance by pointing out that the forms of aphasia in which auditory comprehension loss was a prominent feature also resulted from left unilateral lesions. Dejerine ... showed that the loss of reading comprehension and writing also depended on a left unilateral lesion. Many other observations led to the same conclusion. On the other hand even massive damage to the right hemisphere left language functions unimpaired. . (Geschwind, 1974)

Neurological Evidence: Patients with Lesions

The oldest method of exploring the functional asymmetry of the human cerebral hemispheres is that of analyzing the effects of circumscribed lesions. The most important technique for demonstrating lateralization of functions is Teuber's (1955) inferential technique called "double dissociation". One must be able to show that lesions of one hemisphere cause deficits that are not caused by lesions of the otherhemisphere. A pair of verbal and nonverbal learning tasks clearly demonstrate Teuber's (1955) inferential technique -- double dissociation -- for demonstrating lateralization of function: In this case, the verbal task was to learn strings of digits (Corsi, 1972). Corsi found an impairment on this verbal-learning task after left temporal lobectomy but not after right. In a nonverbal analogue of the task of learning strings of digits, the task was to learn a sequence where the tester had tapped a number of blocks in a random order. On this spatially-cued task, Corsi (1972) found impairment after right temporal lobectomy but not after left.

The best founded asymmetric function of the brain is language. Although language disturbances can come in a variety of forms, they almost invariably involve the left hemisphere. In 1959, Penfield and Roberts compared the incidence of aphasia after surgery to the left versus right hemisphere in patients without brain injury before two years of age. The results overwhelmingly point to left hemisphere involvement in language in left handers as well as right handers (see Table 2-1).

Table 2-1: Incidence of aphasia after surgery on left and right hemispheres of right and left-handers

Side of Surgery	LEFT		RIGHT	
	n	Incidence of aphasia	n	Incidence of aphasia
Right-handed	157	115	196	1
Left-handed	18	13	15	1
Total	175	128	211	2

Kimura and her colleagues (Kimura & Archibald, 1974; Kimura, 1977) found that left brain-damaged patients, whether aphasic or not, had a great deal more difficulty learning a very simple series of motor tasks than did patients with damage to the right hemisphere. On the other hand, patients who had their left temporal lobe removed showed no drop in scores on a musical test of time duration, loudness, timbre, and tonal memory while the right lobe patients dropped significantly (Milner, 1962). Musical skills have been shown to be dissociated from language skills although the recognition of notes and musical dictation are likely to be impaired by left hemisphere damage (Benton, 1977). While right hemisphere damaged patients may be able to speak with correct pronunciation and grammar, a loss of emotional inflection can occur and their ability to judge the emotional tone of sentences said by others is generally worse than that of aphasics (Heilman, Scholes & Watson, 1975).

Adults with left hemisphere lesions will usually obtain significantly lower scores on the Wechsler verbal scale than on the performance scale; patients with right hemisphere lesions will usually show the reverse pattern with lower performance scores (Reitan, 1955). Milner (1968), a neuropsychologist at the Montreal Neurological Institute, demonstrated laterality effects through a study in which patients with left temporal lobe lesions manifested demonstrable impairment of verbal memory but performed normally in remembering and recognizing faces in a delayed matching task. The right temporal lobe lesion patients, by contrast, were unable to recognize and remember the same faces in a collection of photographs although they showed no impairment on tests of verbal recognition and recall.

A warning is given about the possibility of determining the functional capacity of localized areas of the brain by comparing behaviour in "diseased" individuals with that of normals: "...generalizations arising from such comparisons may well be inappropriate. Theoretically at least, it is difficult to determine from such data the manner by which brain tissue, now diseased, previously interacted with broader neural systems." (Rourke, Bakker, Fisk & Strang, 1983, p. 2).

The Study of Split-Brain Patients

The effects of surgical disconnection of the two cerebral hemispheres are reported by various researches (Bogan, 1969; Gazzaniga, 1970; Levy, 1974; Nebes, 1977; Sperry, 1968; Zaidel, 1978a, 1978b). Remarkable and unexpected behavior was noted for these split-brain persons. With the communication channels between the two hemispheres severed, these persons had two independently functioning hemispheres, although the hemispheres had in each case been damaged to some extent by the severe epilepsy which caused the operation to be performed in the first place. Thus it was now possible to explore the capabilities and limitations of each hemisphere.

Through carefully designed studies, Sperry (1968) was able to show that the right hemisphere could perform spatial tasks (draw a figure, recognize faces) but had virtually no language capability. On the other hand, the left hemisphere controlled speech, calculation, and reasoning but could not perform simple spatial tasks. More recent work by Zaidel (1978a) indicates that while the disconnected right hemispheres have no speech, little writing, no grapheme-to-phoneme correspondence rules, and can read practically no sentences, they do have a good grasp of pictorial semantics and surprisingly rich auditory lexicons. In another article, Zaidel states:

> Hemispheric specialization in the disconnected hemispheres is modality- and material-nonspecific. Each hemisphere specializes for a different style of information processing applied to visual and linguistic material alike: the left hemisphere operates by **combinational feature analysis** and the right hemisphere employs **convention-bound template matching** for pattern recognition. Using these different performance strategies the two hemispheres can often reach the same level of competence (Zaidel, 1978b, p. 263, emphasis added).

Nebes (1978) quotes from Levy's 1974 study of commissurotomy patients on tasks where the subject has to pick out a picture of an object which is similar to a given picture.

> "The left hemisphere tends to choose items which are similar in their use -- for example, if shown a cake on a plate it might pick out a fork -- while the right hemisphere selects objects unrelated in use but structurally similar -- a round straw hat with a brim." Levy (1974) reports on a commissurotomized patient who was shown chimeras (composite stimuli composed of two half-pictures, each half to be received by only one hemisphere). The chimeras were to be matched, either visually or conceptually: matching the scissors with a crossed knife and fork would be considered a visual match, matching them with the needle and thread would be considered a conceptual match. Levy concludes "It is clear in any event that a 'match' for the right hemisphere was interpreted in terms of visual similarity and for the left hemisphere in terms of conceptual categorization" (1974, p. 166).

Futhermore, the hemispheres differ in the ways they **think** as well as **perform** (Levy-Agresti & Sperry, 1968; Bogan, 1969). This conclusion holds true for certain non-linguistic capacities in which the left hemisphere is deficient. Levy, Trevarthen & Sperry (1972) found that when a simple match is required, the right hemisphere dominates behaviour regardless of its ability; instructions to **match** two objects seemed to activate the right hemisphere, even when the left hemisphere would have performed better on a certain matching task by using a naming strategy. Another study showed that when the same input and choice stimuli are used under different instruction conditions, hemispheric dominance is controlled by instruction (Levy & Trevarthen, 1976). When told to select choices that look similar to what they have seen (e.g. a hat with a brim when the stimulus is a cake on a roundplate), the right hemisphere dominated but if told to select something that is used with the stimulus seen (e.g. a knife to go with the cake), the left hemisphere dominated.

Even though outwardly the split-brain patients show no obvious undesirable side-effects of the operation, the neuropsychological testing indicates that one half of the each patient's brain is totally unaware of what the other half is doing. These patients would seem, at first glance, to provide excellent conditions for testing the specialization of each hemisphere. One must keep in mind, however, that the original reason for surgical disconnection of the hemispheres was the severity of the epileptic seizures and the ensuing damage. A second possible detriment to generalizing from the results of split-brain studies to normal subjects is that the cerebral hemispheres may not function in the same way when they are disconnected as when they are connected and functioning normally.

Study of Normal Subjects

With normal subjects, the difficulty is to present the stimuli to just one hemisphere at a time or at least to give one hemisphere an advantage in the presentation. Methods have been created for presenting stimuli for visual, auditory or tactile processing with one hemisphere having an advantage over the other.

Dichotic Listening Studies

These studies have consistently found a right ear advantage (REA) for linguistic stimuli and a left ear advantage (LEA) for non-linguistic stimuli (Bakker et al., 1973; Kimura, 1963; Krashen, 1973). The auditory system is not completely crossed in the way that the visual system is, i.e., both hemispheres receive projections from each ear (Kolb & Whishaw, 1980). The connections from the contralateral ear, however, do appear to have preferred access to the hemisphere, so that sounds projected to the right ear are primarily processed by the left hemisphere and vice versa. Kimura (1961) found that when subjects with known left hemisphere dominance for language heard series of pairs of digits, the right ear consistently outperformed the left ear. While the difference was not very great, it was significant and reliable. Dirks (1964) extended Kimura's findings to dichotically presented words.

Melodies (Kimura, 1964) and environmental sounds (Curry, 1967) however, were better perceived by the left ear in normal, right handed subjects. In investigating this phenomenon further, Bever and Chiarello (1974) found that musically experienced listeners recognize simple melodies better in the right ear than in the left, while the reverse was true for naive listeners. They concluded that "the left hemisphere is dominant for analytic processing and the right hemisphere for holistic," i.e., they perceived that musically sophisticated subjects organize a melodic sequence in terms of the internal relation of its components. Bradshaw & Nettleton (1981) cite several studies that reported an LEA for musicians and an REA for non-musicians. They concluded that "It may not be musical training, expertise or talent that determines laterality effects but rather **how** the subject attends to music regardless of these factors. Similar task requirements may induce similar processing strategies in both the experienced and naive listeners and the effects of different task requirements may be determined by the subject's familiarity with the stimulus material itself." Gordon (1974) compared the performance of a mixed group on tests involving melodies and chords. "The present analyses support the idea that there are people who are more capable of using the left hemisphere ... and thus perform well on time-ordering sequential analysis tasks, conversely **right-brained people** would be expected to dominate on tasks which require unitary holistic cognition" (Gordon, 1974, author's emphasis).

Tachistoscopic Studies

The fact that objects seen in the left visual field are projected to the right visual cortex makes it possible to present information independently by using a special instrument known as a tachistoscope. The subject is asked to fixate on a center point marked with a dot or a cross. An image is then flashed in one visual field for about 50 milliseconds. Early studies on visual asymmetries revealed a right visual field advantage (RFA) for verbal material and a left visual field advantage (LFA) for nonverbal material (Witelson, 1977). Horizontally printed script was usually the verbal stimulus while dots, pictures and faces were chosen as nonverbal stimuli. Evidence that perceptually complex stimuli may induce an LFA for verbal stimuli is provided by studies of adults (Bryden & Allard, 1976). In two studies of children (Kershner, Tomae & Calloway, 1977; Carter & Kinsbourne, 1979) a mental set was induced by having the subjects fixate first on either a digit or a nonletter shape prior to the presentation of digits in the hemifields. With verbal priming an RFA emerged but with spatial priming an LFA appeared as though the digits were now perceived as shapes only.

Two studies tested Israeli children, one with elementary age children and one with adolescents. Carmon Nachson & Starinsky (1976) found a slight LFA with beginning readers (of Hebrew) but by grade 5 there was a significant RFA. The other study (Silverburg, Bentin, Gaziel, Obler & Albert, 1979) found the expected RFA in Hebrew but for children just beginning to learn English there was an LFA in English which disappeared as the children became more proficient. Pirozzolo and Rayner conducted a study on a small group of 10 adults using both words and pictures. They concluded "The right hemisphere is superior in carrying out feature analysis; the left hemisphere is superior in carrying out identifications and naming..." (1977, p.259).

In a developmental study of lateralization for recognition of faces, a left visual field superiority was found for 14 and 20 year olds but no visual field difference was found for 8 year olds. The authors concluded that "hemisphere specialization...for recognition of faces involves processes which develop with increasing age through childhood." (Reynolds and Jeeves, 1978, p.520). Other studies, however, have found an LFA as early as 7 years of age with no effect of increasing age (Broman, 1978); Carey, on the other hand, reports that in several studies the ability to recognize faces reached a plateau or decreased from age 12 - 14 before continuing to increase to adult levels (Carey & Diamond, 1980).

Reaction Time Studies

According to Nebes (1977), experiments on normal subjects have shown the two cerebral hemispheres to differ even in their basic means of processing sensory input. Theoretically, an array of sensory stimuli can be dealt with (i.e. identified and an appropriate response programmed) either one at a time in **serial processing** or simultaneously in **parallel or holistic processing.** These two possibilities can be distinguished by measuring in a visual-search task the time necessary to make a decision and by then seeing whether this time lengthens with an increase in numbers of ideas, as it should in serial processing, or is unchanged, as would be predicted in parallel processing. Cohen (1973) found that if normal subjects are shown an array of letters to determine whether they are the same or not, displays falling in the right-half field are processed serially while those in the left-half field are processed in parallel. The most likely explanation for this dissimilarity in search strategies between the two hemispheres is that there are two different ways of treating language material -- verbally and visuo-spatially. Thus, while the left hemisphere goes through and sequentially transforms each letter into an internal acoustic code (i.e. names them), the right hemisphere examines all the letters simultaneously looking for a variation in shape. Nebes' interpretation is supported by the fact that when nonverbalizable shapes were presented, subjects used parallel processing in both fields (Nebes, 1977).

Other reaction time studies (Seamon, 1972; Seamon and Gazzaniga, 1973) have shown that cerebral laterality effects are also functionally related to coding strategies. Subjects were asked to remember two-word pairs either by invoking a verbal rehearsal strategy or a relational imagery strategy. A picture probe was then presented either to the right or to the left visual field. Reaction times were faster for probes presented to the left visual field when the subjects were using relational imagery and faster for probes to the right visual field when the subjects were using verbal rehearsal. From this the researchers inferred a right hemisphere superiority for visually coded information and a left hemisphere superiority for verbally coded information.

Sensory-motor tests

The somatosensory system of fine touch, pressure, pain, and temperature as well as the motor system are arranged so that sensations and movements of the right half of the body are controlled by the left half of the brain and vice versa (Kolb & Whishaw, 1980). These systems can be studied by blindfolding subjects and requiring them to perform various tasks using only the left side or the right. Rudel, Denckla & Spalten (1974) used this technique in studying the tactile sense by testing the ability of sighted children to learn Braille with either the right hand or the left. One might predict that right handed children would be more proficient with their right hands but this was not the case; there was a decided left hand advantage in processing the configurations of bumps which make up a letter in Braille.

Witelson (1977) devised a "dichhaptic stimulation" task in which two different shapes are simultaneously presented one to each hand to be perceived by active touch alone. In one case the shapes would be meaningless and in the other case letters. The meaningless shapes would be identified from a visual array of pictures; the letters would be named. The results showed a left hand, hence right hemisphere, superiority in normal children for meaningless shapes and a tendency toward naming more right than left hand letters on the dichhaptic letters task.

Webster and Thurber (1978) used Witelson's dichhaptic stimulation tasks in a study with adults where half the subjects were instructed to approach the haptic learning task in a **sequential or analytic** manner and half to approach them in a **holistic or gestalt** manner. The results indicated that the degree of left hand superiority was indeed influenced by this manipulation. They concluded that "the results were consistent with the idea that brain lateralization must be defined, not strictly by tasks, but by strategies used by subjects to perform the tasks..." (Webster and Thurber, 1978, p.484).

Concurrent Conflicting Tasks

Several studies have used concurrent conflicting tasks (one reputed to measure left hemisphere processing, one right) to compare the effects of the interference. Kinsbourne and Cook (1971) had right-handed subjects balance a dowel rod on the index finger both silently and while repeating sentences. They found that right hand, but not left hand, balancing was disrupted by the concurrent speech (i.e., balancing duration was decreased). Hicks (1975) replicated and extended this result. He found that increased phonetic difficulty of the verbalized material increased the interference with right-handed performance. Left-handed performance was unaffected at both difficulty levels. The verbalization interfered with both hands of left-handers (who, as a group, have less clearly lateralized verbal function).

Summary of Hemispheric Asymmetry

To summarize the data which seem to indicate that the hemispheres are specialized for different types of processing or for the processing of different content, Table 2-2 has been adapted from a summary table of Kolb and Whishaw (1985).

Table 2-2: Summary of Data On Hemispheric Specialization

Function[1]	Left Hemisphere	Right Hemisphere
Visual system	Letters, words, sentences	Complex geometric patterns, Faces
Auditory system	Language-related sounds	Nonlanguage environmental sounds, Music
Somatosensory system	Tactual recognition of verbalizable shapes (?)	Tactual recognition of complex patterns, Braille
Movement	Complex voluntary movement	?
Memory	Verbal memory	Visual memory
Language	Speech, Reading Writing, Arithmetic	Limited comprehension of language (?)
Spatial processes		Sense of direction, Geometry Mental rotation of shapes
Cognitive processes	Analytical thinking, Sequential processing Verbal labelling Feature by feature analysis	Holistic thinking, Parallel processing

[1] Functions of the respective hemispheres that are predominantly mediated by one hemisphere in right handers

In normal subjects the differences are measured in auditory, visual and sensory-motor modalities but they all point to the same conclusions. Words are generally processed more efficiently in the right ear, in the right visual half-field and there is even a tendency for children to name more letters felt with the right hand. The right hand balancing of a dowel rod is more disturbed by concurrent speech. For subjects using a verbal rehearsal strategy to remember word pairs, reaction time was faster for probes to the right visual field.

Nonverbal tasks, on the other hand, were generally performed better on the left side of the body from which one may infer right hemisphere mediation. There was a left visual half-field advantage for recognition of faces, a left ear advantage for non-linguistic sounds like laughing and crying and also for music with non-musicians, a left hand advantage for learning Braille and for identifying meaningless shapes. For beginning readers in English and Hebrew and also for Hebrew children beginning to learn English there was a left visual half-field advantage. One may conclude that, in beginning readers, there is a need for template matching of the stimuli since they are perceptually unfamiliar to the reader. The style of reading is "sight reading" which is holistic and works only for well known words. Bever and Chiarello (1974) concluded that non-musicians were listening to melodies in a "holistic" manner, and Gordon (1974) spoke of "right-brained" people doing better on tasks requiring "unitary holistic cognition." The fact that subjects using an imagery strategy to learn two word pairs (Seaman and Gazzaniga, 1973) showed a faster reaction time with probes to the left visual field may imply a right hemisphere superiority for visually coded information. Lastly, the fact that the left hand balancing was not disturbed by concurrent rehearsal of verbalized material suggests that the two activities require quite different forms of processing.

Models of Hemispheric Lateralization

To account for the results presented above, several different models of hemispheric processing have been proposed. A summary of Allen's (1983) review of the various models of laterality follows:

1. **Unilateral Specialization Models** imply a real all-or-none difference in the functioning of the hemispheres (Bogen, 1969b; Cohen, 1973; Corballis, 1980; Gazzaniga & LeDoux, 1978; Kimura & Archibald, 1974; Lenneberg, 1976; Milner, 1974; Seamon & Gazzaniga, 1973).

2. **Cooperative Interaction Models** postulate that both hemispheres perform the function simultaneously and that they interact positively (Luria & Simernitskaya, 1977; Chiarello, 1980).

3. **Negative Interaction (Inhibition) Models** state that both hemispheres have the capacity to perform a given function (bilateralization) but that, under normal circumstances, they inhibit or suppress each other's activity (Bogen, 1969a; Kinsbourne, 1970; Kirsner, 1980; Moscovitch, 1976; Studdert-Kennedy & Shankweiler, 1970).

4. **Hemispheric Parallel Models** assume that the two hemispheres are operating simultaneously and independently of each other, either:

   a. With both hemispheres performing exactly the same function (Dimond,1972; Gazzaniga, 1974).

   b. With each performing qualitatively different functions or different components of a superordinate function (Dimond & Beaumont, 1974; Moscovitch, 1979).

5. **Allocation Models** hold that both hemispheres have the capacity to perform a given task but normally only one does so at a time. The allocation may be made early or late in the processing:

   a. **Input Models** where the allocation of the processing to one hemisphere occurs at the beginning of processing. A number of factors are considered to influence the destination:

      i. **Material-Specific Models** where the nature of the stimulus

&/or the task is the basis for allocation (Hines, 1975; Levy & Trevarthen, 1976; Moscovitch, 1973).

ii. **Attention Models** where either hemisphere may be allocated the task (Bever, 1975; Levy, 1974; Moscovitch, 1979).

iii. **Hemispheric Priming Models** where one hemisphere may be primed (aroused or activated) prior to presentation of the of the information to be processed and that this primed hemisphere then takes control of the process (Beaumont, 1981; Hellige, Cox & Litvac, 1979; Kimura, 1973; Kinsbourne, 1978; Moscovitch, 1979; Obrzut, Hynd, Obrzut & Leitgeb, 1980).

iv. **Subject Strategy or Cognitive Style Models** where the allocation decision is internal (within the subject) and may override such factors as the nature of the stimulus or demands of the task (Levy & Trevarthen, 1976; Seamon, 1974; Zenhausern, 1978).

b. **Output and Switching Models** where the final stage of processing, but not necessarily the earlier stages, is hypothesized to be allocated to one hemisphere or the other (Dimond, 1972; Dimond & Beaumont, 1974).

Variations in Hemispheric Asymmetry

The only people who consistently demonstrate the hemispheric laterality patterns presented above seem to be adult right handed males, with normal noninverted hand posture during writing, who have no left handed relatives, were free from birth-stress, whose sensory functions are intact, who suffer no psychotic illness, who were reared in a relatively normal environment and who have no strong preference for either cognitive mode (Levy, 1980). Such individuals probably constitute no more than 15% of the population while the rest show various deviations from this standard pattern. Variations in hemispheric specialization or lateralization have been found in children, females, left handers and dyslexics.

Effects of Maturation

Lenneberg (1967) constructed an argument for early equipotentiality of the cerebral hemispheres that gained widespread popularity. On the other hand, some investigators have suggested that lateralization of function is already present at birth (Entus, 1977; Molfese, 1977) or that the degree of lateralization increases during childhood (Bryden & Allard, 1978; Tomlinson-Keasey, Kelly & Burton, 1978). Satz, Bakker, Teunissen, Goebel & Van Der Vlugt (1975) reviewed four dichotic-listening studies which showed an increase in ear advantage from the age of 6 to 14 and five showing either a mild decrease or a plateau after 3 to 5 years of age. Another measure of change in lateralization with age has been the study of evoked potentials (EP) to speech and nonspeech stimuli conducted by Molfese, Freeman & Palermo (1975). They found the size of the EP to greater in infants, less in children aged 4 to 11 years and even less in adults. They concluded that maturation of the cerebral commissures may cause the age-related decline.

In a developmental study of lateralization for recognition of faces, a left visual field superiority was found for 14 and 20 year olds but no visual field difference was found for 8 year olds. The authors concluded that "hemisphere specialization ... for recognition of faces involves processes which develop with increasing age through childhood." (Reynolds and Jeeves, 1978, p. 520). Other studies, however, have found an LFA as early as 7 years of age with no effect of increasing age (Broman, 1978); Carey, on the other hand, reports that in several studies the ability to recognize faces reached a plateau or decreased from age 12 - 14 before continuing to increase to adult levels (Carey, 1981).

Kinsbourne & Hiscock (1981), after reviewing the literature conclude that:

> The traditional concepts of equipotentiality and progressive lateralization have been discredited by a rapidly expanding body of experimental evidence. Despite a few inconsistencies and lacunae in the data, it seems clear that brain function is lateralized from birth, if not earlier, and that language does not become increasingly lateralized as the child matures. (p.152).

Kolb and Whishaw (1985) have recently presented an overview of cognitive development including the **equipotential** theory which states that either hemisphere can be specialized for language or nonlanguage functions, the **left-for-language** theory which postulates that the left hemisphere is special and is organized genetically for language development while the right is a dumping ground for left-overs, and the **parallel-development** theory which suggests that both hemispheres play special roles, the left being destined to specialize in language and the right in nonlanguage functions. Kolb and Whishaw find that a parallel development theory which initially permits some flexibility or equipotentiality (in the event of damage to one hemisphere) "most usefully encompasses most of the data." They propose a hierarchy in which:

> At birth the two hemispheres functionally overlap because each is processing low-level behaviors. By five years of age the newly developing higher-order cognitive processes have very little overlap, and each hemisphere thus becomes increasingly specialized. By puberty each hemisphere has developed its own unique functions (Kolb & Whishaw, 1985, p. 621).

Another area of study and conjecture over cerebral differences in the developing brain has been the matter of comparative maturation of the hemispheres and the resulting effect on their specialization. Some investigators feel that the slow maturation of the neocortex and the interhemispheric fibers leads to differential development of the two hemipheres during postnatal development (Trevarthen, 1974). There is some controversy, however, about the characteristics of the differential development.

Bever (1975) cites two studies (Crowell, Jones, Kapunai & Nakagawa, 1973; Seth, 1973) which seem to show that the right hemisphere functionally matures earlier than the left. Bever (1975) proposes that the hemisphere which matures later (the left) will be more adaptable and, thus, "at birth the left hemisphere is more able to deal with and develop mastery over mental activity." Kaufman builds on this case and argues that the more adaptable hemisphere (left) will be more susceptible to cultural deprivation, an argument that would be supported by Pizzemiglio's (1971) study that found a "Lateralization Effect" to appear at age 5 in his upper-socioeconomic group and not until 7 in the lower. Reynolds & Kaufman (1980) conclude that since the right hemisphere seems to mature earlier younger children should be able to process spatial stimuli better. Segalowitz (1983) cites Giannitrapani (1967) as stating that "a faster developing right hemisphere would predispose it to dominate in the infant's treatment of its early visual environment, that hemisphere would be more likely to deal with the other most important aspect of the infant's life -- its affective ties."

Other researchers, on the other hand, have proposed that the left hemisphere develops earlier and "gains a competitive advantage in the acquisition of motor representation" while the later maturing right hemisphere is assumed to have "an advantage in the establishment of sensory-affective synaptic representation" (Bogen, 1982). Goldberg & Costa (1981) also conclude that the right hemisphere matures later but their reason is that it contains more associative cortex which, according to Conel (1939), is the last to mature in ontogenesis. Corballis (1981) seems to support the hypothesis that the left hemisphere matures earlier in speaking of the left hemisphere's "more evolved functions" and concluding that the right hemisphere's specialization for some functions occurs by default because of the left hemisphere's prior commitments. One is left with the impression that neither the data nor the theories are clear as to whether one hemisphere matures earlier than the other, and, if so, which one is the earlier maturing and what are the implications of earlier or later maturation.

Waber investigated the effects of early or late maturation on children, conceptualizing females as a population of early maturing individuals and males as a population of late maturing individuals (Waber, 1976, 1977). She found that the late maturers did better on the spatial than the verbal tests while the early maturing group show verbal better than spatial. Within each sex, late maturers scored better than early maturers on each of the spatial ability tests, but none of the groups scored better on any of the linguistic or motor-sequencing tasks.

A factor which complicates the measure of lateralization of function is the difficulty in determining the strategies used by children at various stages which may change the approach to a task from verbal-analytical to spatial-holistic regardless of the nature of the stimuli. Tomlinson-Keasey, Kelly & Burton (1978) investigated hemisphere specialization for processing visually-presented words using a three-stage approach: grade 3 children, junior high students and adults. Children in third grade used global, undifferentiated holistic methods with no specialization for words or matches. These results confirm those of Carmon, Nachshon & Starinsky (1976) who found an LFA at grade 1 for letters only but an RFA for letters did not appear until children were in grade 5. They suggested that advanced readers generate left hemisphere strategies to verbally encode and sequentially process letters and words. Since they found no effect of opposite scanning for Hebrew and Arabic, they concluded that "hemispheric specialization in verbal perception is the underlying source of laterality differences". They inferred that the developmental progression from LFA to RFA is due to the acquisition and development of symbolic processing skills. Bakker and his colleagues came to a similar conclusion on the basis of a study involving a dichotic listening test and a word-naming task with children in grades 2 to 5 (Bakker, Teunissen & Bosch, 1976). They found reading proficiency to be associated with a right ear advantage in grade 3 girls and grade 5 boys but with either a LEA or REA in grade 2 girls and grade 3 boys. Thus they concluded right hemisphere dominance for language to be appropriate for early reading but that only left hemisphere dominance favours advanced reading. Because of the danger of inferring too much from the results of a dichotic listening test, a better way of stating the case might be that while the use of strategies appropriate to the right hemisphere can lead to early reading proficiency, advanced reading proficiency requires the use of left hemisphere type strategies for the processing of verbal material.

Effects of Gender

Moore (1967) inferred that intellectual development in girls takes place primarily through linguistic channels. In boys, by contrast, nonverbal skills play a relatively prominent role. Lansdell's (1962) findings could be seen as evidence that females, in making esthetic judgments, rely more on left hemisphere language modes and males rely almost purely on right hemisphere modes. Hutt showed the early developmental differences in this way:

> When boys are still concerned with active exploration of their environment and with perceptual and motor skills, the girls are becoming increasingly adroit in their verbal and social functions (Hutt, 1970).

Mellone (1944), in a factor-analytic study of 10 year old school children's performance on 14 picture tests, found three factors: a general factor, school learning, and a space factor. The general factor was present in all picture tests for both boys and girls. On the school learning factor, however, different picture tests loaded for boys and girls: for girls, those tests requiring the understanding and recall of precise verbal instructions; for boys, completing patterns of crosses and rings and block counting. The third factor appeared **for boys only** : a space factor, involving the ability to manipulate given material through visualization alone. The boys were superior on some of these tests but not on others. Mellone concluded that even if girls lack the visual-manipulative ability possessed by boys, they "can yet succeed in these tests by use of their general intellectual ability" (Mellone, 1944, p. 14). The latter part of this statement could be reworded in terms of hemispheric processing: girls can succeed in visual-manipulative tests by using left hemisphere processes.

Harris suggests that

> if females are **neurologically** disposed to be better in linguistic than visuospatial skills, and (because they are maturationally more advanced) to acquire language earlier than males, it is reasonable that they ultimately come to depend on linguistic modes more than males do and in more situations ... such dependency can work to the female's disadvantage in problems for which linguistic modes are less efficient (Harris, 1978, p. 481).

There is some indication that the right hemisphere of boys matures earlier than that of girls as shown by greater left-sided perceptual asymmetries for spatial material at younger ages (Witelson, 1976). On the other hand, earlier and more pronounced left hemisphere maturation in girls was inferred from greater perceptual superiorities for verbal material (Kimura, 1967; Bryden, 1970). The apparently differing maturational rates of the two sides of the brain in boys and girls are consistent with the gender differences in the maturation of verbal and spatial functions (Levy, 1980).

Evidence suggests different within-hemisphere organization for males and females: females exhibit smaller and less consistent hemispheric asymmetries on both verbal and nonverbal tasks (Bryden, 1966; Kimura, 1973; McGlone & Davidson, 1973; Levy & Reid, 1978).

The main effect of less lateralization for language in females is that the incidence of aphasia in women after left hemisphere damage is only one-third that in men (McGlone, 1977, 1978). Because there does appear to be a reliable female verbal superiority and male spatial superiority, this pattern suggests that a "specialization of the right hemisphere for nonverbal functions may be advantageous for space perception and that males more often than females have this type of neural organization" (McGlone & Kertesz, 1973). Levy (1980) concluded, however: "It should be kept in mind that the within-sex variance in cerebral and cognitive organization is probably much larger than the between-sex variance and that, for this reason, every individual, whether male or female, must be judged for herself or himself alone."

Effects of Handedness

Far greater differences in lateralization are found in left-handed individuals. Levy (1980) states that "approximately 89% of the population appear to be genotypic dextrals, of whom 99.67% have left hemisphere language dominance. Of the 11% non-dextrals, about 56% have left language dominance and 44% right language dominance" (p. 137). Data from the Wada test for lateralization of language have been collected for more than twenty years (Rasmussen & Milner, 1977). They found that 96 per cent of right-handers have shown left lateralization for language while the rest show right. In left-handers the figures are 70 per cent and 15 per cent with the remaining 15 per cent showing bilateral representation. These data are consistent with the data showing that left-handers do not usually suffer as much aphasia from left hemisphere damage as right-handers (Hecaen & Ajuiaguerra, 1964). Levy and Reid (1976) investigated inverted and normal writing postures and found that individuals who use the normal writing posture have their language hemispheres contralateral to the writing hand while those who use an inverted posture have their language hemispheres ipsilateral to the writing hand. Further, they found that 66% of left-handed males but only 31% of left handed females have this inverted writing posture. This result implies that right hemisphere language is more frequent in left handed females than in left handed males (Levy & Reid, 1976).

Variations in Children with Reading Disabilities

Another field in which attention has been paid to hemispheric lateralization is that of reading disabilities in children. One of the first investigators to propose a link between lateralization and reading disability was Orton (1937) who concluded that poor readers suffer from the effects of incomplete cerebral dominance. With the development of behavioral tools to study hemispheric asymmetry, it has become possible to test more directly the idea that reading disability is linked to atypical cerebral asymmetry.

Dichotic listening tasks have been used in many studies comparing good and poor readers. A number of studies show a consistent REA for normal children but no advantage or a weaker LEA for poor readers (Bryden, 1970; Thomson, 1976; Witelson & Rabinovich, 1972; Zurif & Carson, 1970) but some have found no difference at all (Davidoff & Done, 1981; Witelson, 1977a).

Lateralized tachistoscopic presentation has also been used to investigate hemispheric asymmetry in dyslexic children. Using letters and words as stimuli, several studies have pointed to greater right visual field superiorities in normal readers (Marcel, Katz & Smith, 1974; Marcel & Rajan, 1975; Miller & Turner, 1973) while others have reported a larger right visual field effect in dyslexics than in normals (Yeni-Komshian et al., 1975).

Witelson (1977a) compared dyslexics and normals on a dichhaptic stimulation task. When given two novel forms to feel simultaneously, one in each hand, normal children were better able to make a visual match to the form held in the left hand but dyslexics showed no difference. Witelson concluded that there may be bilateral representation of spatial functions in dyslexics. From a verbal dichotic listening task she inferred specialization for linguistic functions in dyslexics although their skills were less well developed. In another article (Witelson, 1977b), she suggested that what develops is cognitive skill and that as skills appropriate for analytic-sequential processing develop, they are lateralized to the left hemisphere.

A number of other studies have indicated a developmental trend toward a stronger REA (Bakker, Teunissen & Bosch, 1976; Reitsma, 1975) and also a stronger RFA (Tomlinson-Keasey & Kelly, 1979; Tomlinson-Keasey, Kelly & Burton, 1978) in older more fluent readers. These authors and also Sadick & Ginsburg (1978) postulate that bilateral control of language may be advantageous to the early development of reading skills, and that poor readers are slower to progress to left hemisphere control of language.

In a book review, Satz (1983) takes issue with Bakker (1981) for inferring right hemisphere specialization for speech from a left ear advantage:

> This position confers considerable surplus meaning to a construct which is already based on a performance variable of questionable validity....the conditional probability that a left ear advantage is associated with right hemisphere speech ... is in the order of $p<.10$. in other words, one would be wrong 90% of the time given this test sign and the expected low prior probability of right hemisphere speech in the normal dextral population (Satz, 1983, p. 291-292).

While much research has dealt with dyslexics or poor readers as though they belonged to a homogeneous group, a number of researchers have been seeking ways of subdividing children who have moderate to severe difficulty in learning to read (Aaron, 1978; Bakker, 1981; Boder, 1973; Pirozzola, 1979; Rourke, 1982). In some studies the subgroups are classified, a **priori**, according to differing abilities on verbal and spatial tasks (Aaron, 1978; Kinsbourne & Warrington, 1963; Mattis, French & Rapin, 1975; Pirozzola, 1979; Rourke, 1982) and in some studies similar discrepencies between verbal and spatial skills appear in **ex post facto analyses** (Boder, 1976; Bakker, 1981; Doehring et al., 1979; Petrauskas & Rourke, 1979; Rugel, 1974; Watson, Goldgar & Ryschon, 1983). The general pattern, however, seems to be that there are groups of disabled readers who perform better on spatial tasks than verbal (Aaron's "analytical-sequential deficient", Boder's "dysphonetics", Bakker's "P" type, Pirozzolo's "auditory-linguistic dyslexics", Rourke's "PI" type), those who perform better on verbal than spatial (Aaron's "holistic-simultaneous deficient", Boder's "dyseidetics", Bakker's "L" type, Pirozzolo's "visual-spatial dyslexics", Rourke's "PA" type), and those who don't perform well on either (Boder's mixed type), plus those with other patterns of disabilities (Petrauskas & Rourke's 2, 3, & 5 types).

Of these, the first group, which has better spatial skills and deficient linguistic skills, seems to be the largest and contains a disproportionate number of boys (Boder, 1976; Mattis, French & Rapin, 1975). Using the Children's Test of Hemispheric Dominance (Zenhausern, Note 1), Oexle & Zenhausern (1981) found equal proportions of right and left hemispheric activators among good readers but only 15% of the poor readers showed a preference for left hemispheric activation while 85% were classified as "Rights". In the only study which seems to show different proportions, Watson and her colleagues (1983) found more poor readers to have a "visual processing deficit" than a "generalized language disorder" but 43% of the sample was classified as having minimal dysfunction. Witelson (1977a) suggests that dyslexics may read predominantly with a spatial-holistic cognitive strategy neglecting phonetic-sequential strategies. Satz and his colleagues explained developmental dyslexia as "a delay in those crucial early sensori-motor and later conceptual linguistic skills which are intrinsic to the acquisition of reading and which are triggered by a lag in the maturation of the cerebral cortex" (Satz, Friel & Rudegair, 1974a). Friedman, Guyer-Christie & Tymchuk's (1976) results support the "maturational lag" theory of learning disabilities.

Psycholinguists (Fries, 1963; Smith, 1971) have argued that initial and advanced reading differ: perceptual analysis is much more prominent in early reading than in fluent reading. If so, one would predict different hemispheric processes to subserve reading depending on the prominence of the various aspects of written language (Bakker, 1981). Children entering elementary school have experience processing both language and visual form precepts. They are then required to learn "a complicated, arbitrarily organized system of visual signs and symbols which must become intimately associated with a previously learned auditory-vocal language system according to a rigidly prescribed and sometimes contradictory set of rules" (Belmont, 1974, p.535). Rourke (1982) has postulated that a right hemisphere orientation is needed in the early stages when reading is a novel and predominantly visual-spatial task; in the intermediate stages, the right hemisphere is involved in assembling graphemes for linkage with phonemes, the left hemisphere utilizes routinized descriptive systems and contributes speed to the decoding of words and phrases. For reading comprehension, Rourke suggested that the most efficient system would be "to have the left hemisphere sytems automatized, thus 'freeing' one to concentrate on and emphasize the functioning of right hemisphere systems and their unique role in dealing with novelty, informational complexity, and intermodal integration (i.e. achieving new meanings from the text" (Rourke, 1982, p.6). Given the complexity of the reading task, it is not surprising that some children have difficulty learning to read. Given the importance of reading in our culture, it is not surprising that a lot of energy has been devoted to the early identification of children with potential reading problems (De Hirsch, 1957; Denhoff et al., 1971; Francis-Williams, 1970; Jansky, 1983; Naidoo, 1972; Richardson, 1983). Adapting the methods of teaching reading to the identified cognitive processing skills of individual children is beginning to show some promise, both with regular reading classes (Zenhausern & Markman, 1983) and with remedial teaching (Bakker, 1982; Zenhausern & Sinatra, 1983).

PREFERENCE FOR COGNITIVE MODE

> In our society we have developed what is considered a cultural gap between two styles of thinking. One is characterized by an orderly mentality -- epitomized by professionals such as lawyers, accountants and scientists. The other is characterized (or perhaps caricatured) by an attempt to avoid an emphasis on strict order and logic -- as with artists and musicians. There is supposedly a great gulf between them, the one grasping its cold, analytical, verbal approach to life, the other its emotional, holistic, imagistic attitudes (Segalowitz, 1983).

These two styles are highly reminiscent of the cognitive modes, specializations attributed to the left and right hemispheres. Several researchers have investigated this predeliction or bias toward use of one or other cognitive mode. Bogen (1969) coined the term "hemisphericity" to denote a bias toward use of one of the hemispheres, whether right or left. Gazzaniga (1977) suggests that a particular child might be able to solve a problem using verbal symbols with greater ease than visual-spatial ones, while another child might be better off solving the same problem using visual-spatial relations.

Reynolds (1981) has offered the following definition of "hemisphericity":

> the tendency of an individual to rely primarily upon the problem-solving or information-processing style of one or the other hemisphere in the course of normal daily functions. It is vital to understand that hemisphericity is

> conceptualized as a type of dominance for an information-processing style and is independent of traditional notions of cerebral dominance and unrelated to the motorically determined lateral preference of the individual (p. 111).

Bogen, DeZure, TenHouten, and Marsh (1972) first described the concept of hemisphericity as defined above and attempted to estimate relative hemispheric utilization by constructing an A/P ratio of performance on an apropositional task, Street Gestalt Completion Task (Street, 1931), to performance on a propositional task. WAIS Similarities, (Wechsler, 1955). High ratios (larger numerator) were interpreted as signifying greater reliance on right hemisphere processing; lower ratios (larger denominator) were believed to signify greater utilization of left hemisphere thinking. The results of comparing different cultural groups showed Hopi Indians to have the highest ratio, followed by urban black women, urban black men, rural whites and urban whites. Bogen and his colleagues concluded that Hopis and Blacks rely more on their right hemispheres in thinking than do the other groups. While the A/P ratio does not seem to have been validated in follow-up studies, at least it was an attempt to quantify the tantalizing concept of individual hemisphericity, the "tendency for a person to rely more on one hemisphere than the other" (Bogen et al., 1972).

Ornstein and Galin (1975) compared two occupational groups, ceramicists and lawyers, hypothesizing that they would show opposite hemisphericity. While the groups showed no difference on their dependent measure (left/right eye movements), the lawyers did score higher on the verbal task, "writing from memory", than the spatial, Kohs Block Design (Goldstein and Scheerer, 1953) and the ceramicists scored higher on the spatial than on the verbal task. The lawyers were also more likely to sort by words than shapes.

The next step was to compare various groups on hemisphericity and lateralization to see whether neurophysiological correlates could be found to differentiate cognitive styles. Dumas and Morgan (1975) measured alpha suppression in left cortical areas as artists and engineers performed tasks associated with the left hemisphere (mathematics and linguistics) and the right hemisphere (face recall and a modified Nebes Ring Test). While both groups showed the expected pattern of reduced alpha in the left hemisphere during left hemisphere tasks and vice versa, there was a tendency for engineers to rate the left hemisphere tasks as easier and artists found the right hemisphere tasks to be easier.

Arndt and Berger (1978) stated that since cognitive mode was measured for groups and not individuals in two research studies (Bogen et al., 1972; Galin & Ornstein, 1974), "direct evidence to support the assumption that an individual's cognitive mode is related to actual asymmetry in cerebral functioning" was not provided. They reanalysed the data of Dumas and Morgan (1975) and found no individual differences. They then tested 24 right-handed males ages 20-30, sculptors, psychologists and lawyers, on two laterality measures using the visual half-field technique, one requiring the discrimination of faces and the other of letters. In addition they gave each subject three tests of spatial-holistic skills and three of verbal-analytic skills. Unfortunately, one of the choices for a verbal-analytic test of left hemisphere processing was the WAIS Block Design, a test better characterized as spatial-holistic (see Chapter 3 for a discussion of the rationale for including the WISC-R Block Design as a measure of spatial-holistic processing). On the basis of a Composite Index (the sum of the three spatial-holistic tests divided by the sum of the three verbal-analytic tests), a median split was used to divide individuals into two "cognitive mode" groups. All groups showed the expected lateralization with a right hemisphere superiority for face discrimination and a left hemisphere advantage for the letter task; there was no effect of occupation or cognitive mode and no significant interaction. The design would have been stronger with a better chance of showing an effect of cognitive mode if only those subjects showing a significant imbalance between spatial-holistic and verbal-analytic processing efficiency had been included rather than taking a median split.

The lawyers did tend to do better on verbal-analytic tasks, however, and sculptors on the spatial-holistic tasks. Segalowitz (1983) asks the following question: "Does this mean that when given a choice, the lawyer types will activate the left hemisphere more than the right hemisphere?" He believes it does citing Dabbs (1980) who found that, while resting, the amount of blood flow to each side of the brain differs for English majors and architecture majors. Using the temperature technique, he found that English majors have a higher blood flow to the left hemisphere and architecture majors to the right. Presumably, while resting in a comfortable position, they think about things they prefer. Springer and Deutsch (1981) caution that "effects suggesting differential hemispheric involvement as a function of occupation are generally weak and have failed to replicate in some studies."

Zenhausern (1978) has proposed a model of hemispheric dominance based on the hypothesis that for a right-dominant individual visual images are essential to thinking and deductive reasoning is the preferred mode; for left-dominant individuals visual images play an ancillary role and inductive reasoning is preferred. Zenhausern then developed a paper and pencil questionnaire to measure behavioural correlates of the differential efficiency of the two hemispheres classifying subjects into right and left activators. Zenhausern and Repetti (1979) found that subjects who reported that they thought in pictures scored higher on the right scale of the "Style of Learning and Thinking" Test (Torrance, Reynolds, Riegel and Ball, 1971) and subjects who reported they did not think in pictures scored higher on the left scale. Using this classification Coleman and Zenhausern (1979) compared left and right activators on a lateralized retrieval task using response latency as the dependent variable. They found the two groups differed on processing speed and the strength of a left hemisphere bias induced by a verbal memory load. The superiority of the left hemisphere for left dominants was four times as great as for right dominants. Zenhausern and Nickel (1979) found that right activators learned a finger maze in fewer trials, in less time and with fewer errors than left activators. Zenhausern, Notaro, Grosso and Schiano (1981) presented left and right activators with auditory messages in which there was a conflict between verbal content and emotional tone of voice. Overall, rights responded significantly more often to the inflection cues and lefts more often to the verbal content.

In a study employing the lateral eye movement technique with undergraduate students, Gur and her colleagues found that "right movers" and "left movers" tend to seat themselves in classrooms in order to accommodate their preferred direction of gaze, right movers on the left and left movers on the right (Gur, Gur and Marshalek, 1975). Those who showed no overall seating preference chose seats consistent with hypothesized hemisphere activation required for that topic, on the left for verbal-analytic topics (mathematics and natural sciences) and on the right for more holistic topics (art and social sciences).

Attempts have also been made to relate hemisphericity or cerebral lateralization to Witkin's cognitive style measure, field-dependence being considered analagous to the style of the right hemisphere and field-independence analogous to that of the left hemisphere. Cohen, Berent and Silverman (1973) studied patients who were to undergo electro-convulsive therapy (ECT) to one hemisphere for treatment of severe depression. The twelve patients whose left side had been administered the ECT, making the left hemisphere dysfunctional, presumably had more active right hemispheres and showed higher field-dependence scores; the opposite was true for the others. "Extrapolating to normals," Segalowitz (1983) states, "we would conclude that field-independent people would show more left hemisphericity than field-dependent people who would prefer a right hemisphere mode of functioning, including a predeliction for visual spatial tasks over verbal tasks." Berent and Silverman (1975) attempted to investigate this question using the rod-and-frame test to divide female undergraduate students into extreme field-dependent and field independent groups. Their scores on two paired associates learning tasks, one verbal and one "visuo-perceptive," were compared. Only the verbal test distinguished between the two cognitive style groups with the field-dependents doing more poorly than the field-independents, while both groups performed adequately on the visuo-spatial test, thus partially confirming the hypothesis. Segalowitz cited Dawson (1977) as providing cross-cultural support in a study of Eskimos where relationships were found among laterality, handedness and field dependence.

Without offering supporting evidence, Reynolds states that hemisphericity "seems well established in most children by 3 1/2 - 4 years of age" (Reynolds, 1981, p.112). This claim does not seem to have been corroborated in the literature as yet. Ways of measuring hemisphericity, especially in children, are very new and not yet well validated. Preliminary norms for a children's form of "Your Style Of Learning And Thinking" were only published in 1979. In 1981 and 1982, Dombrower and colleagues have been attempting to determine the construct validity of other measures hypothesized to represent an orientation to right, left or integrated brain function in primary school children. To date, their success has been limited. Oexle (1981) used the "Children's Test of Hemisphere Preference" (Zenhausern, 1978) to assess normally intelligent third and sixth grade right handed boys' hemisphere preference. While the 20 good readers were equally divided (9 to 11) between right and left hemisphere activators, 17 of the 20 poor readers were right activators. The subjects were then given a lateralized manual reaction time task that required semantic encoding; i.e. they were to indicate by pushing a toggle switch whether pictures of words (one in upper case, one in lower) or shapes (two identical), projected to one visual half-field, were the same or different. "The analysis indicated that sixth graders reacted faster than third graders, responses to geometric forms were faster than responses to words, and stimuli projected to the left hemisphere had shorter latencies than stimuli projected to the right hemisphere. There was, however, no significant difference between good and poor readers (Oexle & Zenhausern, 1981). Unfortunately, no analyses are reported for the effect of hemispheric activation on reaction time of the group of good readers where a comparison could have been made.

With regard to the relationship between choice of profession and hemispheric balance, Segalowitz asks: "Could it be that the pattern of relative skill is due to some brain determinant?" He suggests three logical possibilities cautioning that there is not much basis for supporting one over the other:

> 1. It may be that one hemisphere's strength (not yet defined except in circular terms) is focused on because of inherent biological factors. A 'strong' hemisphere may be dominant generally, encouraging the person to use one cognitive style over another.
>
> 2. It may be that one hemisphere becomes more efficient or dominant through practice, where the decision to practice a skill is made for nonbiological reasons, such as reinforcement or availability.
>
> 3. A third possible relationship between hemispheric representation and skill level is that the choice may be only one of mind, not brain, and that no permanent changes accrue from extra use of one hemisphere's skills (Segalowitz, 1983, p. 208).

Segalowitz goes on to ask how we can avoid the confounding of "input strategies, processing strategies and true lateralization, a confounding that comes from using a single measure of lateralization." He proposes the use of "relative measures" citing a repeated measures design (Segalowitz & Orr, 1981) where input and output requirements were held constant and only the content of the stimulus (verbal versus spatial) was varied. The two subjects showed considerable variation over time but a consistent pattern with the verbal stimulus producing a greater left hemisphere advantage than the right. The pattern was consistent across the two subjects, despite the fact that one showed a general right visual field advantage (all positive scores) and the other a left visual field advantage (all negative scores). Other researchers have also stated the advantages of sampling the relative efficiency of the two hemispheres (Bentin & Gordon, 1979; Hartlage & Reynolds, 1981). Thus, while their hemisphericity differs, their pattern of lateralization is the same. Segalowitz concludes "With this research approach, it would be possible to examine differences between left- and right-handers without the problem of attentional biases. Similarly the issues of sex and cognitive style differences can be addressed without the main variable turning into an artifact (Segalowitz, 1983, p. 232-3).

EDUCATIONAL EFFECTS OF HEMISPHERICITY

Sperry (1973) relates hemispheric specialization to education saying: "our education system, as well as science in general, tends to neglect the non-verbal form of intellect. What it comes down to is that modern society discriminates against the right hemisphere."

Wittrock introduced three relations between education and the cognitive processes of the brain:

1. that "process-oriented paradigms are useful in study of the ways human learners construct meaning from instruction";

2. that "recent research on the brain is consistent with some findings in cognitive psychology regarding cognitive models of learning and memory";

3. "research on the human brain is consistent with some ancient ideas about the art of teaching. These ancient yet current ideas emphasize the **importance of the mental elaborations of the learner** ... The mental transformations performed by different people determine whether instruction is rote or meaningful, whether it stimulates verbal or spatial processes, and whether it facilitates learning and memory" (Wittrock,1978,p. 63-64, emphasis added).

Wittrock goes on to review several interesting lines of research on the cognitive processes of the human brain. The first is that the brain actively selects, transforms, organizes and remembers information. The recent findings about the hemispheric processes of the brain present a new perspective on some earlier results in psychological research on verbal processes and imagery in learning, encoding, and memory. Recent brain research suggests that it is not only the verbal or spatial mode of the information but, more important, the type of organization or transformation performed upon it that characterizes its constructed and remembered meaning.

The Raven's Progressive Matrices, for example, may be solved in a sequential analytical manner using verbal mediation, or they may be solved in a holistic fashion using spatial-holistic processing. In the latter case, the subject is likely to "know" the answer but be unable to tell how the answer was determined. Spatial-holistic processing may work well in simpler, more obvious problems but as the figures or matrices become more complex, verbal-analytical processing may be more effective. Hunt (1974) considered what sort of computer program could solve problems presented in Raven's Progressive Matrices. Analysis disclosed that a score within the normal adult range on the test could be obtained through the application of either a gestalt algorithm based on manipulating visual images or a reduced analytic algorithm based on applying formal operations. He concluded that the failure of the Raven test to differentiate between these two styles of problem solving casts doubt on its use as a measure of intelligence. On the other hand, the fact that either method can be used successfully, might recommend its use as a "general" measure of intelligence which does not favour one form of processing over the other.

Research that focuses on the different processes used by learners may lead to an understanding of why some of them are having trouble learning. Before the hemisphere processing paradigm was developed, several researchers had concluded that development of a representational system precedes and forms a foundation for language development. If good connections were not made between the nonverbal and verbal systems, then the system that was better developed would more likely be used in problem solving. Other researchers have also recognized that some people show a strong bias toward using either Verbal-Analytic and Spatial-Holistic strategies for processing information (Friedman et al., 1976; Guyer and Friedman, 1975; Harris, 1978; Witelson, 1976; Wittrock, 1978).

Wheatley et al. discuss the implications for the mathematics curriculum. "If a young child relies more on right-hemisphere processing he may be more successful in a curriculum that stresses spatial presentations and multisensory learning. It may also be productive to match the mode of presentation with the child's preferred mode of learning" (Wheatley et al.,1978,p. 29).

Guyer & Friedman found some support for the hypothesis that learning disabled children may attempt to use nonverbal cognitive abilities in school tasks. They found significant correlations between tests of academic achievement and a test of visual closure in the learning-disabled group of 7 to 12 year old boys but not in the control group. They concluded that "the importance of visual closure for the learning-disabled groups suggests the use of this ability as a strategy, albeit a not very successful one, in coping with academic tasks" (Guyer & Friedman, 1975, p. 663). Lezak (1976) reports that adult patients with right hemisphere lesions do more poorly on two tests of visual closure (Mooney "Closure Faces Test" & "Street Completion Test"). Ornstein (April, 1979, personal communication) uses a visual closure test as a measure of right hemisphere functioning. Thus, Guyer and Friedman's (1975) research suggests that learning disabled children are likely to use the less appropriate spatial-holistic strategies of the right hemisphere in coping with academic tasks which require verbal-analytic strategies for efficient processing.

SUMMARY

Specialization of the cerebral hemispheres for certain functions has been documented and summarized in Table 2-2 above, with the left hemisphere regarded to be more efficient in language, complex voluntary movements, sequential and analytical processing and the right hemisphere in recognition of complex geometric patterns, faces, music, mental rotation of shapes, parallel spatial-holistic processing. Variations in hemispheric asymmetry have been discussed with regard to the effects of maturation, gender, handedness and reading disabilities. Even though one may not be justified, therefore, in assuming that the left hemispheres of a mixed group of children are always responsible for verbal-analytic processing and the right hemispheres for spatial-holistic processing, one may still study the cognitive processes regardless of their location in individual brains.

While researchers have demonstrated that individuals may have stronger

Verbal-Analytic (V-A) or stronger Spatial-Holistic (S-H) skills, and that some individuals may regularly prefer to utilize either V-A or S-H skills regardless of the type of problem, no clear relationship has been demonstrated between the presence of an imbalance between the skills and a preference for the better skill. That relationship remains to be studied more extensively.

Many authors have expressed their concern that children with stronger Spatial-Holistic and weaker Verbal-Analytic skills may be at a serious disadvantage in our schools (Sperry, 1973; Wittrock, 1978; Wheately et al., 1978). On the other hand, it may be that the efficiency of spatial-holistic processing is more important in the initial stages of learning to read when the task is a novel one of perceptual analysis (Bakker, 1981; Fries, 1963; Rourke, 1982; Smith, 1971). According to Rourke (1982), both hemispheres are needed for reading in the intermediate stages: the right in assembling graphemes for linkage with phonemes, the left contributing speed to the decoding of words and phrases. During the intermediate stages, then, one might expect children with equal V-A and S-H skills to be better readers but this remains to be investigated.

3. METHODOLOGY

This chapter has been divided into four main sections: the study, the tasks, the sample and the procedures used to investigate the construct validity of the F-F Preference Test. The first section includes the rationale for the study, assumptions, definitions and hypotheses. The second section describes the tasks that were used to measure balance in cognitive processing skills and gives a rationale for the choice of each task. The criteria for selecting the sample are outlined below including the characteristics of each Reading and Cognitive Balance Group. The final section details the procedures used for construct validation including the substantive, structural and external components.

THE STUDY

In Chapter 2 a summary of the literature regarding specializations of the cerebral hemispheres was presented. A fairly consistent pattern appeared for right handed adult males but other groups such as children, left handers, females, and dyslexics showed some inconsistencies. The special groups chosen for investigation in this study are school-age children with stronger Verbal-Analytical or Spatial-Holistic skills or equal skills, both with and without reading problems. Since the focus of the researcher is on cognitive processing and not neuropsychology, location of processing in the brain is not presently being investigated, even though the processing modes of interest are characteristic of one [illegible] other of the hemispheres. The F-F Preference Test has been devised to measure a preference for a mode of processing: either Verbal-Analytic or Spatial-Holistic. The purpose of this study is to develop the F-F Preference Test, investigate its structural validity through reliability and item analyses and then to estimate the effects of age, cognitive processing balance and reading achievement on Function or Form preferences.

Research Design

The research design chosen to investigate the external component of construct validity is a "Three Factor Fixed Effects" design with 3 levels of Cognitive Processing Balance, 2 levels of Reading Achievement and 5 levels for Age -- a total of 30 cells. A schematic representation including the number of subjects in each cell is portrayed in Table 3-1.

Table 3-1: Research Design: Three Factor Fixed Effects

Cognitive Balance	Reading Achievement	Age					n
		5	6	7	9	11	
Stronger V-A	Good	8	9	8	7	9	41
	Poor	10	9	9	6	7	41
Equal	Good	9	9	9	8	9	44
	Poor	5	9	9	6	9	38
Stronger S-H	Good	8	9	5	6	9	37
	Poor	7	7	7	9	9	39
Total n		47	52	47	42	52	240

Definition of Terms

1. Verbal-Analytic Processing -- a mode of processing which includes a combination of analytical processing and verbal content.

    a. **Verbal** -- includes language functions of various degrees of complexity, both expressive and receptive: verbal coding, verbal memory, ability to categorize and conceptualize in words.

    b. **Analytic** -- a feature-by-feature analysis in which attention is given to parts rather than wholes, abstracting out relevant details.

2. **Spatial-Holistic Processing** -- a mode of processing which includes a combination of holistic processing and nonverbal content.
    a. **Spatial** -- processing which tends to be visual or kinesthetic involving the ability to see and store patterns or create images.
    b. **Holistic** -- processing in which attention is given to wholes rather than parts; also called global or Gestalt synthesizing.
3. **Intellectual Skill Level** -- a subject's estimated I.Q. extrapolated from a subset of Wechsler subtests, the two V-A tests, and the two S-H tests.
4. **Cognitive Processing Balance** -- the relative strength of Verbal-Analytic versus Spatial-Holistic processing skills. The size of the difference between V-A and S-H skill levels large enough to be considered significant is discussed and defined below under Sample Selection Criteria.
    a. **Stronger V-A** -- skill on V-A tests is significantly higher than skills on S-H tests, regardless of the general skill level.
    b. **Equal** -- level of achievement on the V-A tasks is not significantly different from that on the S-H tasks.
    c. **Stronger S-H** -- skill on S-H tests is significantly higher than on V-A tests, regardless of the general skill level.
5. **F-F Bias**
    a. **Function Bias** -- the subject shows a preference by choosing 50%

or more Function rather than Form matches on the F-F Preference Test.

b. **Form Bias** -- the subject shows a preference by choosing 50% or more Form rather than Function matches on the F-F Preference Test.

6. Reading Achievement

a. **Good Reader** -- a child who performs at or above the 50th percentile on a standardized reading test.

b. **Poor Reader** -- a child who performs at or below the 30th percentile on any subtest of a standardized reading test, has repeated a grade or is in a Special Class.

Assumptions

The main assumption is that the four tests chosen to measure Verbal-Analytical and Global-Spatial cognitive processing skills do indeed perform this task. The rationale for the selection of each test is detailed below. A second assumption is that a choice of Function on the F-F Preference Test involves the use of Verbal-Analytic processing and that a choice of Form involves the use of a Spatial-Holistic processing mode. A third assumption is that the pattern of choosing Form or Function on the F-F Preference Test is not significantly influenced by uncontrolled intervening variables such as gender and handedness. Fourthly, since no standardized reading scores were available to compare children who have repeated a grade in school with their chronological age-mates, it was assumed that repeaters can be considered to be Poor Readers in comparison with children of the same chronological age who have not repeated a grade.

Hypotheses

The major research question involves the effect of Cognitive Processing Balance on preferences tapped by the F-F Preference Test. In the light of the literature cited in Chapter 2, a uni-directional effect can be hypothesized for this effect (see Hypothesis #1). Since the literature indicates that age and reading achievement affect hemispheric lateralization and since the F-F Preference Test is posited to measure a preference for processes normally lateralized to the left hemisphere (Function) or right hemisphere (Form), the effects of these variables will also be estimated, but as no direction is indicated clearly in the literature, null hypotheses will be tested for the effect of these variables (Hypotheses #2 to #7).

1. Cognitive Processing Balance significantly affects F-F Preference Test scores in the following manner:
    a. Stronger Verbal-Analytic ability is correlated with a Function Bias on the F-F Preference Test.

    b. Stronger Spatial-Holistic ability is correlated with a Form Bias on the F-F Preference Test.

2. Age has no statistically significant effect on F-F Preference Test scores.

3. Reading Achievement has no statistically significant effect on F-F Preference Test scores.

4. The interaction between Cognitive Balance and age is not statistically significant.

5. The interaction between Cognitive Balance and Reading Achievement is not statistically significant.

6. The interaction between Age and Reading Achievement is not statistically significant.

7. The three-way interaction between Cognitive Balance, Age and Reading Achievement is not statistically significant.

TESTS OF V-A AND S-H PROCESSING

Four Wechsler subtests were administered in a search for subjects with stronger Verbal-Analytic skills, stronger Spatial-Holistic skill, or a balance between the two. For measuring Verbal-Analytic processing, the Vocabulary and Similarities subtests of the WPPSI and WISC-R were chosen. To measure Spatial-Holistic skills, the Block Design subtest of the WPPSI and WISC-R and the Object Assembly subtest of the WISC-R were used. The justification for using each of these tests is detailed below:

1. **VOCABULARY** (Verbal-Analytic Processing)

    a. **Cognitive rationale.** This is a test of word knowledge and linguistic skill which may involve a variety of cognitive functions or features, including learning ability, fund of information, richness of ideas, memory, concept formation and language development (Sattler, 1974). By inference it reveals classificatory and conceptualizing skills (Zimmerman & Woo-San, 1973).

    b. **Structure of Intellect Dimensions (SOI).** The SOI classification of the Vocabulary subtest (Sattler,1974) is Cognition of Semantic Units (CMU) -- the ability to comprehend the meanings of words or ideas.

c. **Advantages.** The advantages of including the Vocabulary subtest as a measure of V-A processing are:

i. It has the highest reliability of all the subtests– 0.82 on the WPPSI, 0.86 on the WISC-R and 0.95 on the WAIS.

ii. It loads on Cohen's (1959) Verbal Comprehension II factor and it also loads on Bannatyne's (1974) Verbal-Conceptual factor. These factor loadings imply a strong verbal component to the subtest.

iii. While Vocabulary loads on Cohen's Verbal Comprehension II, Similarities loads on Verbal Comprehension I, implying that they are measuring different cognitive processes. Other indications of independence are the different "rationale" of each test and the different SOI classifications.

iv. Like all other highly verbal tests, it is relatively sensitive to brain lesions of the left hemisphere (Parsons, Vega & Burn, 1969, cited in Lezak, 1977).

d. **Disadvantages.** The main disadvantage of including both Vocabulary and Similarities is that the average correlations between them are among the highest for all the subtests: 0.53 for WPPSI, 0.67 for the WISC-R and 0.75 for the WAIS. Since a correlation of 0.70 implies that 50 % of the variance is common to the two subtests, then one can infer that 50 % of the variance is independent for each test. While the overlap is relatively high, it is not too surprising in two tests where verbal ability is so crucial.

2. SIMILARITIES (Verbal-Analytic Processing)

a. **Cognitive Rationale.** The Similarities subtest requires verbal concept formation (i.e., abstract thinking) and logical thinking. Concept formation is a function that permits the individual to place objects and events together in meaningful groups (Sattler, 1974). Separation of essential from nonessential features enables qualities or levels of intellectual functioning to be distinguished (Zimmerman et al., 1973). Younger subjects will tend to give concrete rather than abstract similarities, e.g., a coat and a sweater are alike because they both have sleeves.

b. **Structure of Intellect Classification.** The SOI classifications of the Similarities subtest (Sattler, 1974) are Cognition of Semantic Relations (CMR) -- the ability to see relations between ideas or meanings of words, Cognition of Semantic Transformations (CMT) -- the ability to see potential changes of interpretations of objects and situations, and Cognition of Symbolic Relations (CSR) -- the ability to see relations between items of symbolic information. Besides CMR, CMT, and CSR, the Similarities subtest of the WPPSI is considered to be classified as Convergent Production of Semantic Systems (NMS) -- the ability to order information into a verbally meaningful sequence (Sattler, 1974).

c. **Advantages.**

i. The Similarities subtest is a good measure of verbal ability which is particularly analytical, e.g., "separation of essential from nonessential features". The SOI classifications of EMR, CMT, and CSR all imply the need for analytical and verbal ability.

ii. Lezak (1977) reports that the Similarities subtest "is one of the best WAIS predictors of dominant hemisphere disease" (p. 208). Thus the left hemisphere (of 97 % of right-handers) seems to be mediating the cognitive processing of similarities.

d. **Disadvantages.** The only disadvantage seems to be the same as that listed for Vocabulary, i.e., that 50 % shared variance is higher than one might wish.

3. **BLOCK DESIGN** (Spatial-Holistic Processing)

a. **Cognitive Rationale.** The Block Design subtest can be interpreted as measuring perceptual organization, spatial visualization ability, and visual-motor coordination. Block Design loads strongly on Cohen's (1959) Perceptual Organizational Factor and Bannatyne's (1974) Spatial Ability Factor. However, Witkin (1965) has reasoned that the Block Design measures analytic thinking. Sattler(1974) conceives of it as a "concept formation task involving both analysis and synthesis." Lezak (1977) points out that right hemisphere damage affects even the simplest designs unless the relationships can be verbalized while left hemisphere damage only affects the most difficult designs that are conducive to verbal analysis.

b. **Structure of Intellect Classification.** The SOI classifications of the Block Design subtest are Cognition of Figural Relations (CFR)

-- the ability to recognize figural relations between forms, and Evaluation of Figural Relations (EFR) -- the ability to choose a form based on the evaluation of what the relations are between the figures or forms in the sequence.

c. **Advantages**

i. The high loadings of Block Design on factors of spatial ability (0.66) confirm the importance of this test as a measure of perceptual organization.

ii. Lezak (1977) reports the Block Design subtest of the WAIS to be one of the best measures of visuo-spatial organization. Since the major functions of the right hemisphere are concerned with spatial perception and visual organization, and, since these functions are included in the definition of Spatial-Holistic cognitive processing, therefore, Block Design should be a good measure of it.

d. **Disadavantages** A disadvantage of using Block Design to measure S-H processing is that there seems to be a fairly strong analytic component to the test. Block Design has the highest correlation (0.58) with the Total Verbal Score implying that there is a moderate degree of overlap with skills used on the verbal tests. Because of this correlation, Arndt & Berger (1978) even selected Block Design as a measure of left hemisphere functioning -- a choice which seems to be based on a misinterpretation of the work of McFie & Zangwill (1960) which points not only to lower scores on the Wais Block Design subtest with damage to the left parietal lobe but also to marked depression of the scores with right hemisphere lesions (see also Lezak, 1976, p. 220). It follows then that subjects with stronger V-A skills and poorly developed spatial skills will have depressed scores on the Block Design subtest even though they can manage the analytical component of the test.

4. OBJECT ASSEMBLY (Spatial-Holistic Processing)

a. **Cognitive Rationale.** The Object Assembly subtest is a test of perceptual organizational ability. The visual organization seems to play a **productive** role, because something must be produced out of parts not immediately recognizable. In solving the jig saw puzzles, subjects are required to grasp a whole pattern by anticipating the relationships among the individual parts (Sattler, 1974). Thus, object assembly requires a form of visual closure while also requiring visual-motor coordination (since speed gains bonus-points).

b. **Structure of Intellect Classification.** The SOI classifications of the Object Assembly subtest are Cognition of Figural Systems (CFS) -- the ability to comprehend arrangements and portions of visual objects in space; Cognition of Figural Transformations (CFT) -- the ability to visualize how a given figure or object will appear after given changes, such as unfolding or rotation; and Evaluation of Figural Relations (EFR) -- the ability to choose a form based on the evaluation of what the relations are between the figures or forms in the sequence (Sattler, 1974).

c. Advantages

i. Object Assembly is considered to be a good measure of Perceptual Organization (Cohen, 1957), Spatial Ability (Bannatyne, 1974) and of Visual Organization (Rapaport et al., 1976). Since all of these concepts fit under the rubric of spatial-holistic-parallel cognitive processing, Object Assembly seems to be a good choice for a task to measure S-H processing. In addition to these results from factor analyses, neuropsychologists indicate that Object Assembly is particularly sensitive to nondominant hemisphere lesions (Lezak, 1977, p. 224).

ii. Since the balance between V-A and S-H skills is not considered to be related to intelligence, the fact that Object Assembly is considered to be a poor measure of g may be an advantage rather than a disadvantage.

Disadvantages

i. Speed seems to be a variable that may cause Object Assembly scores to be depressed for reasons irrelevant to the balance between V-A and S-H processing. Lezak (1977) reports that "The speed component probably underlies the association of lowered Object Assembly scores with frontal lobe lesions..." (p. 224). It may be, of course, that it is the planning component as well as the speed that causes frontal lobe involvement to lower the scores.

ii. Another component of Object Assembly is similar to Block Design -- it, too, can be done analytically. This applies especially to puzzles which have features printed on them, i.e., all but the Horse in the WISC-R. The same argument holds, however, as was put forward for Block Design: since using only an analytical method in Object Assembly is inefficient, those with stronger V-A skills should not do as well on Object Assembly as they do on the V-A tests.

iii. As the WPPSI does not include an Object Assembly Subtest, raw scores on the WISC-R were extrapolated downwards to produce scaled scores for 5 year olds, a manipulation of the results which might affect those scores.

THE SAMPLE

A number of schools were chosen to provide breadth in socioeconomic levels in the sample: three Edmonton Public Schools and one school in Sherwood Park. The Sherwood Park school and Garneau School in Edmonton would contain upper socio-economic families while Norwood and Grace Martin contain a large proportion of children from lower socio-economic groups.

Selection Criteria

Criteria for stratification of the sample by Age, Cognitive Balance, and Reading Achievement are detailed below.

1. Age. Children were tested at the end of Kindergarten, and after one, two, four and six years in elementary school. Mean ages of each age group are as follows:

   FIVES : 5 yr 4.5 mo to 6 yr 4.5 mo
   SIXES : 6 yr 4.5 mo to 7 yr 4.5 mo
   SEVENS : 7 yr 4.5 mo to 8 yr 4.5 mo
   NINES : 9 yr 4.5 mo to 10 yr 4.5 mo
   ELEVENS: 11 yr 4.5 mo to 12 yr 4.5 mo

2. Cognitive Processing Balance. Four subtests of the WISC-R were administered in a search for subjects for the Stronger Verbal-Analytic, Stronger Spatial-Holistic and the Equal Group. The total of the scaled scores on the Spatial-Holistic tests (Block Design & Object Assembly) was subtracted from the total of the scaled scores on the Verbal-Analytic tests (Vocabulary & Similarities) to produce a Difference score. Subjects were then assigned to Cognitive Balance groups on the basis of the size and direction of Difference scores. An arbitrary cut-off score of 4 difference points was chosen after considering the following information:

a. The Mean Standard Error of Measurement for the four tests across ages is approximately 1.4 (Wechsler, 1974, p. 30),

b. The differences between individual subtests required for significance at the 15% level range from 2.35 to 3.13 (Wechsler, 1974, p. 35),

c. The Standard Error of the Differences between the means of the two sets of subtests at the 15% level of significance range from 2.68 to 3.02,

d. A cut-off score of 5 difference points (the most reasonable considering the above information) would place only 16% of the sample into the Verbal-Analytic group and 19% in the Spatial-Holistic group.

Thus, an absolute difference score of 4 points was chosen as the criterion:

Difference less than -3 .... assigned to V-A group

Difference -3 to +3 .... assigned to Equal group

Difference greater than +3 ... assigned to S-H group

3. **Reading Achievement.** The kindergarten children were selected for the study in May by their teachers on the basis of their skills in pre-reading tasks. The Poor Group consisted of children whose parents were being advised by the kindergarten teachers to hold their children back for another year in kindergarten as they were coonsidered not yet ready to learn to read, usually because of a lack of maturity. The Good Group consisted of children about whom the teachers had no doubts about their readiness for reading.

Children in grades one to six were selected on the basis of their performance on standardized tests of reading, i.e. the Edmonton Public School Board Reading Test (Edmonton schools, all grades), the Metropolitan Achievement Test (Sherwood Park, grades 1-3) or the Canadian Test of Basic Skills(Sherwood Park, grades 4-6), except where these were unavailable (repeaters and children in special classes). These tests had been administered to the children by school personnel in the month prior to the selection of subjects for this investigation.

Good Readers were defined as children who had never repeated a grade in school and whose total reading score was at or above the 50th percentile or the 5th stanine for their grade level. Poor Readers have been defined as children whose scores on either the decoding or comprehension subtests place them at or below the 30th percentile or whose total reading scores on the Metropolitan Achievement Tests were below the 4th stanine, Representatives of the Edmonton Public School Board Testing and Evaluation Department advised the experimenter that children scoring above and below these limits would represent Good and Poor Readers, respectively. The anomalous group in-between was not included in the study. In all cases, the assignment to reading groups was verified by the classroom teachers before the children were included in the study. Children whose reading problems were caused by the fact that English is their second language were excluded from the sample.

TEST DEVELOPMENT AND VALIDATION PROCEDURES

The model of test development utilized here is that of Loevinger where the construct validity of the test implies not only test analysis but also the process of the construction of the test. She states that the construct validity of a test has three aspects or components: (1) the substantive component, similar to what was previously called content validity, (2) the structural component, concerned with homogeneity and functional unity, and (3) the external component, including relations to non-test behavior, factorial patterns and relations to other tests. "None of these steps in test construction is optional and none is without consequence for the validity of the test in use" (Loevinger, 1957, p. 654).

Prior to outlining the steps in the construction process of the F-F Preference Test, however, one must focus on construct validation theory on which the construction of a test is based. It is the objective of this chapter to present a brief theoretical framework of construct validity, and then to outline specifically the steps in the development of the F-F Preference Test.

THEORETICAL BACKGROUND OF CONSTRUCT VALIDITY

In order for data used in research to be meaningful, the instruments used to collect the data must meet the requirements of good tests. The main criteria are the test's reliability and validity. The first major paper in the area of construct validity was that of Cronbach and Meehl (1955) in which they treated construct validity as one of four types of validation. Their effort was aimed at explaining the concept and at elaborating on its implications in response to the first Technical Recommendations for Psychological Tests and Diagnostic Techniques (1954). They described construct validity as the type of validation involved "whenever no criterion or universe of content is accepted as entirely adequate to define the quality to be measured" (Cronbach & Meehl, 1955, p. 282). Thus construct validity is necessary whenever the trait under observation cannot be measured directly. They then proceeded to place construct validity within the philosophical framework of the nomological network in which emphasis is placed upon sufficient elaboration of the theory concerning the construct in question. Not only must the construct occur within a nomological network, but it must also be related to observable behaviors.

Loevinger (1957) attempted to define further the term "construct" in an attempt to avoid possible problems surrounding previous definitions. She elaborated on a method of construct validation that includes content and criterion validation as well as internal consistency. She stated that there are three main components to the construct validation of a psychological test and that it is necessary to investigate these components in a specific sequence:

1. **The Substantive Component** -- The construct must be derived from an explicitly formulated, theoretically based definition of a trait. This definition is then translated into a large sample of items which are designed to serve either as behavioral representations of the trait or signs of the trait's presence. This is what is often referred to as content validity.

2. **The Structural Component** -- Concern is focused on the internal consistency or homogeneity of the scale as well as its factor structure. Internal consistency is concerned with reliability and the factor structure with construct validity. The structure of the measuring instrument must be consistent with the structure of the construct.

3. **The External Component** -- External validation is concerned with what most investigators call criterion-related validity and construct

validity, and includes non-test behavior, factor patterns, and relations or correlations with other tests.

One of the main differences between Loevinger's model and other models is the difference between **empirical** and **substantive** item selection in developing the item pool. Jackson (1971) clarified this difference by referring to Meehl's (1945) statement regarding the construction of personality tests where Meehl argued for empirical item selection saying that a person's response to an item is in itself an interesting piece of data whose behavioral correlates must be uncovered empirically. While an item may not appear to have face or content validity, the fact that it discriminates empirically between a criterion group and a control group is all that is needed for it to be included in the test. "A corollary of this approach is that items completely lacking in any rationale, or items which might even appear to be opposite from what might be expected from the theory, are permitted with this technique" (Jackson, 1971, p. 231).

Jackson supported Loevinger's recommendations for substantive item selection. Underlying this position is the belief that the most effective way to measure a trait is to assess the behaviors that are most relevant to that trait. The substantive approach places a large responsibility on scale developers in that they must be thoroughly aware of both what the trait is and what the trait is not. The relationship of the item to the criterion is logical in nature. The definition of the trait must be translated into a large sample of items designed to serve as a comprehensive representation of that trait. Jackson argues that the chances of an item failing when administered to a new sample are greatly reduced by using the substantive method of item selection.

In summary, then, the construct validity of a test, i.e., its validity as a measure of real traits, is seen by Loevinger (1951) as having three aspects: the substantive, structural and the external components.

A. The Substantive Component

The substantive component is the extent to which the content of items included in the test can be accounted for in terms of the trait believed to be measured in the context of a particular psychological theory. Loevinger concludes "The final selection of items shall be made, however, on the basis of empirical findings. The substantive component of validity is the ability of a theory to account for the resultant content; it cannot be determined unless the pool of items is broader in scope than the test" (1957, p. 661). This section will show how the sample of items has been generated and tested with various groups.

Test Development

A case-study approach was used in the early development of items for the F-F Preference Test. Such an approach implied the close observation of individuals who took the test, and retrospective analyses of their responses to each item; for example, a lawyer who was highly analytical and verbal could be expected to have a preference for functional relationships; an artist who was highly visual could be expected to show a preference for form matches. The developing test was tried out with different kinds of individuals: old-young, male-female, etc. The test continually underwent revision during this process with the researcher always keeping in mind the theory which formed the basis of the test. It was advantageous to test people whose normal behavior was familiar to the tester to produce a phenomenological form of external validation for the test results.

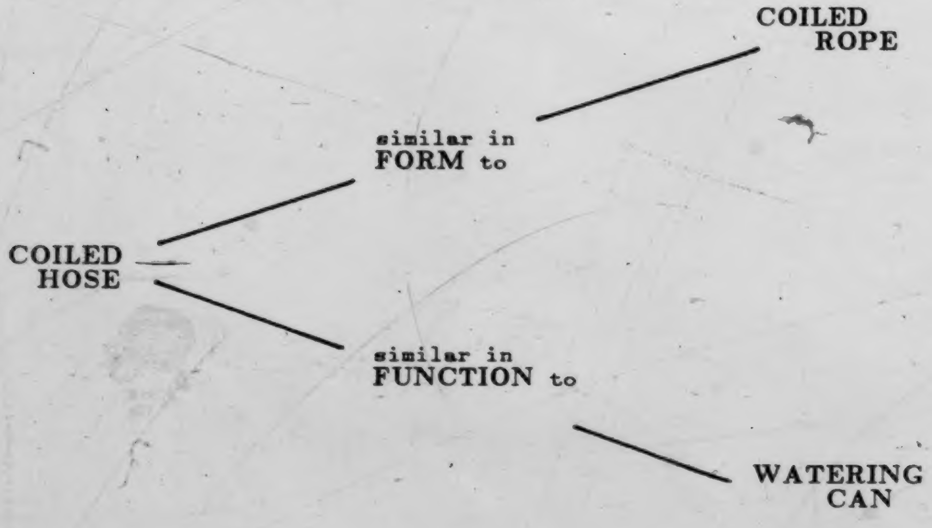
The first set of items were based on the model used in Levy's (1974) Structure Functions Matching Test where the pictures in set B could be matched by appearance to those in set A or by function with those in set C (see Fig. 3-1).

Additional items for the test were developed according to the principle that each set of three objects must be related in that manner:

A similar in FORM to B similar in FUNCTION to C

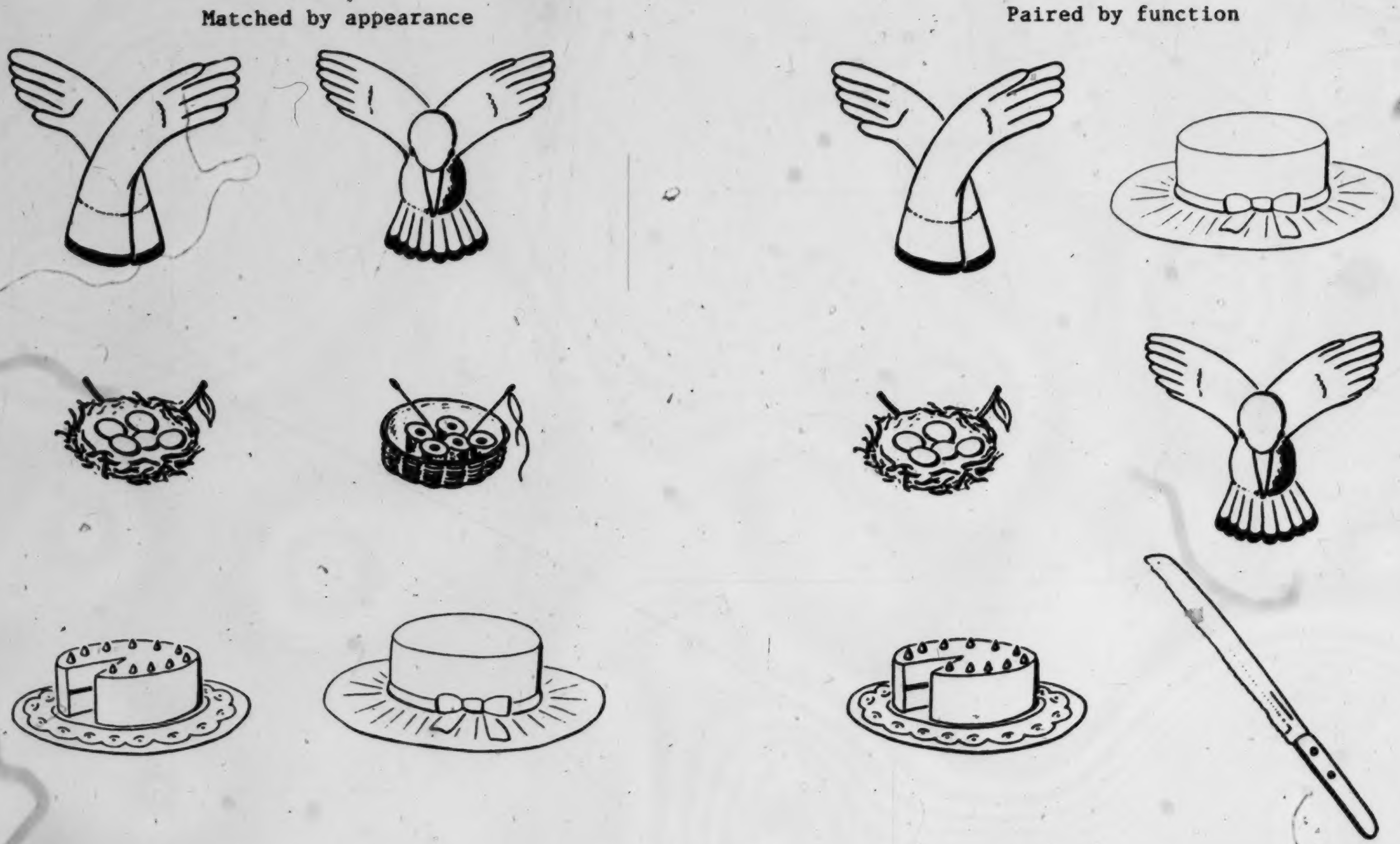
Thus,

A a COILED ROPE, B a COILED HOSE C a WATERING CAN



F-F Preference Test Items

Sets of pictures which are associated by Form or Function and which were used as test items are portrayed in Figure 3-2, and 3-3: the complete test is to be found in Appendix 1. The functional choice to go with each visual match was a **nominal** association like "book-book", a **categorical** association like "orange-banana", or a **relational** association like "cake-knife". A ten-item test was first constructed with the pictures arranged so that the single picture was shown first and taken away; the two possible matches were then shown and the individual was asked to point to the picture "that goes better with the first picture".



Matched by appearance
Paired by function

Figure 3-1. Test items after Levy's (1974) Structure Functions Matching Test.

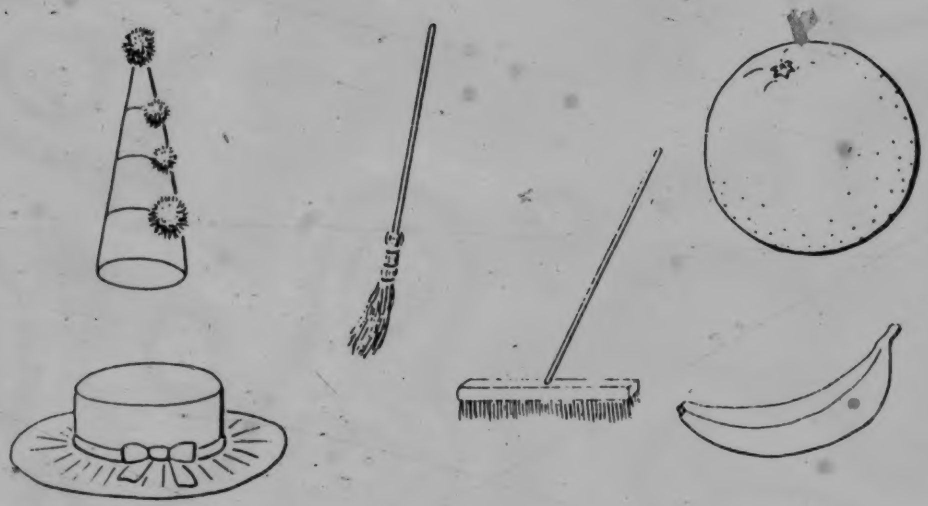


Figure 3-2. Pairs of stimuli representing Function matches.

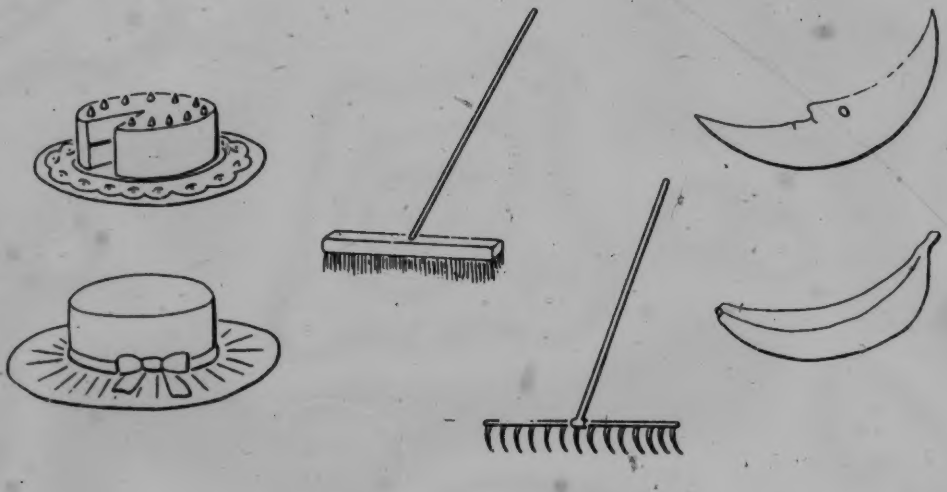


Figure 3-3. Pairs of stimuli representing Form matches.

Version 1 was tried out with several adults. Some people had difficulty choosing between Form and Function or would choose some of each. Some consistently chose Form and others Function. The results with Version 1, therefore, showed some people having a preference for Function and others a preference for Form, but the test at this stage was too short and the choices were too obvious. Twenty-one items and 19 distractors were then generated for the test. A set of instructions in English and in Dutch were produced for the testers. Several members of the Paedologisch Instituut in Amsterdam tried the test out with their own children.

In generating Form matches, attention was paid to whether the similarity came more from the outer dimensions, e.g. orange-ball, from the inner dimensions, e.g. nest-basket, or a mixture of the two e.g. bird-glove. The Form pairs limited the possibilities for Function matches but if the Function pairs were to represent V-A processing it was important to use various methods of classifying and various levels of difficulty because the test was designed to start with five year olds.

Categories of Function Choices

The Function choices in the F-F Preference Test fall into four classes. They are presented in detail in Table 3-2.

1. The simplest category **Identical** contains pictures of the same object in two different forms, e.g., a closed banana and a peeled banana or a closed book and an open book.

2. The next stage, the **Nominal** category, includes two objects of the same name but very different appearance: rake-rake, hat-hat.

3. A **Categorical** association is one in which each item of the pair belong

to the same superordinate category: snake & lizard being animals, banana & orange being fruit; or objects that have the same use: a hose & watering can both water plants, a nest and a birdhouse are both for baby birds, a knife and scissors are for cutting.

4. The **Relational** category consists of objects that are related in some other way, e.g., bird goes with nest, knife goes with cake.

Table 3-2: Categories of Function matches

Identical	Nominal
#13 book-book	#34 broom-broom
#11 banana-banana	#38 rake-rake
# 7 snake-snake	#36 cake-cake
#16 hose-hose	# 5 bird- bird
	#40 hat-hat
Categorical	**Relational**
#35 orange-banana	#38 round cake-knife
#24 snake-lizard	#18 square cake-knife
#41 knife-scissors	#37 bird-nest
#23 moon-stars	
#45 hose-watering can	
#21 nest-birdhouse	

In a pilot study the F-F Preference Test was given to a group of young children in order to determine whether or not 4 to 6 year olds could indeed make both Form and Function choices -- otherwise one could not correctly speak of the child as having a preference for one or other combination. The theory discussed in Chapter 2 suggests that the conceptual choices are within the capabilities of most five year olds. The test was divided into two parts, each having approximately the same number of identical, nominal, categorical and relational associations in the Function matches. Ten four year olds, 22 fives and 22 sixes were tested. First the test was given with the child being asked to point to the picture that "goes together better" with the upper picture. The pictures were arranged so that the single picture was in view at the same time as the two matching choices. On the second run the distractors were skipped but for each item the child was asked to cover one picture and then tell how the other two pictures go together. Then the process was reversed. One child who was not quite four had difficulty in switching from a Form comparison to a Function comparison, but this rarely happened with the other children. If the child was looking for visual likenesses in a conceptually matched pair the tester would say "Yes, but they don't really look much alike. Is there some other way in which they go together?" All the children were then able to identify the functional associations, even the most difficult: oranges and bananas are both fruits or "you eat them both". Sometimes the children could not give a name to a picture (lizard or push broom) but they usually knew enough about it to make the functional association. Thus the theories were borne out that the young children could all express both associations with all items. A choice of one item or the other could then be called a "preference".

Several ambiguities in the pictures showed up in the children's explanations. A fan-shaped leaf had been paired for shape with a Japanese fan versus a narrow leaf. Some children saw the fan-shaped leaf as a tree and not as a leaf. The second problem, in comparing the fan-shaped leaf with the fan, was that some children said "You can wave the leaf like a fan." Those ambiguities provided sufficient reason to eliminate both items from the test. Another item had a rake compared with a broom and a pile of leaves. The combination rake-broom (see Fig. 3-3) was supposed to be a visual match but one child, just turned five, apparently made a visual choice and then gave a logical reason for the choice: "They are both tools." The possibility of ambiguity in the Form choice caused the item to be eliminated and, for a similar reason, the one where there was a rake to be compared with a push broom and a girl holding a whisk broom.

Version II was also given to a dozen adults who were tested as a group, scored their own tests, and then discussed the results. A result of the discussion was to eliminate a canoe that had been a visual match for the banana. There was an overwhelming preference for the moon as a visual match. It was obvious that a few people had made a rule for choosing Form or Function. The effect of a decision to use a rule was to eliminate the spontaneous choice on individual items. In one case, a man who had a strong preference for verbal-analytic processing decided to choose Form but half-way through the test he forgot his rule and reverted to his natural preference for Function. This showed that his verbal-analytic bias was sufficiently strong to over-ride his rule, evidence of external validity of the test. It was obvious that better distractors were needed, however, to discourage creation of rules for choosing Form or Function. Since the original set of distractors were all geometric forms, it seemed important to produce distractors that used the stimulus items in different combinations. The rationale for choosing which bird to put with the nest, or for choosing the snake or hose to go with the rope (Fig.3-4) are not particularly obvious and have little to do with form or function.

Since the theory of hemisphericity or preference for cognitive mode is not concerned with memory abilities, Version III was arranged with both the stimulus and the two response choices visible simultaneously.

Final Test

At this stage of the development of the test the items were deemed satisfactory, i.e., all the associations could be made by five year olds, there were no ambiguities in the pictures or between visual and conceptual choices, the distractors were able to confuse adults who searched for a rule, the test was long enough to allow for reasonable reliability and short enough to require only 10-15 minutes to administer. An attempt was made, therefore, to arrange the items in the best order

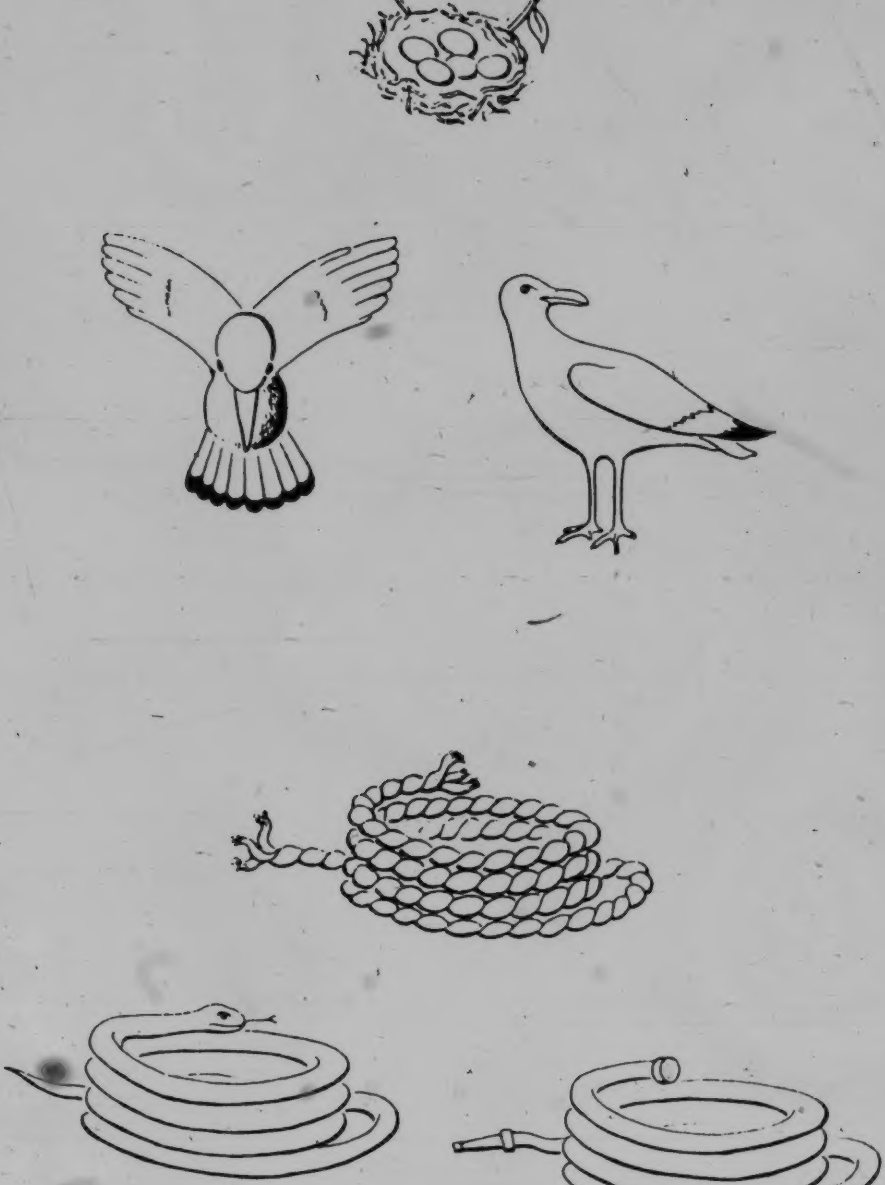


Figure 3-4. Examples of F-F Test Distractor Items.

possible. The first four items, used as examples, were originally chosen from among the distractors because they drew a majority of children strongly one way. The new order of these four items was such that a majority of respondents would select the left, then the right, then left again and right again. This order should work against the establishment of a set toward automatically choosing the picture to the left or the right.

The test items were then randomly distributed throughout the test with the proviso that no more than two consecutive test items would be allowed, and that no identical visual matches would follow each other. When the original items were constructed, the placement of the Form and Function choices were divided, i.e., in the two snake items, the visual match (coiled rope) would appear to the left once and to the right once. Thus there are 10 Form choices on the right and 11 on the left, plus 19 Distractors for a total of 40 items.

The distractors were originally randomly distributed throughout the test. In asking subjects about some of the items and distractors, however, it became obvious that the reasons for choosing some distractors reflected the respondent's cognitive bias. Thus people with a Form bias would give some kind of visual description as to why they chose the snake-rope combination (#39, see Fig. 3-4), the banana-cake choice (#34), or one of the oblique lines to go with A horizontal one (#37). People with a Function bias would be more likely to give a logical reason in the first two and a non-logical reason in the case of the lines. Thus, these distractors seemed to provide corroborating evidence of the presence of a bias. Questions on the last seven items then became an integral part of the test, to check on the subject's reasons for making each choice. This gave the subjects a chance to show a bias or non-bias in their explanations.

Even though the instructions were to treat each set of items separately and not make a rule, the following questions were added at the very end of the test: "Did you make a kind of rule for choosing? If so, when did you start using it? What was the rule?" Where subjects had a rule for choosing Form or Function, or an arbitrary rule such as "choose two left and then two right", the test was considered invalid.

A final addition was to get correct identification of each picture from a set of the stimuli shown at the very end of the test (see Appendix I). Any picture incorrectly identified would have resulted in the appropriate items being dropped and the score pro-rated or, if necessary, the complete record being dropped. In some stimuli where the picture was used only as a visual match, such as the gloves or the sewing basket, an accurate and detailed description of the picture was not deemed necessary. Where the item was a functional match, however, it was necessary for the item to be correctly identified, e.g. the lizard must at least have been seen as an animal.

B. The Structural Component

In demonstrating the structural component of construct validity it is important to show that the **theory** is tested and not just that the **test** is tested. Because the research design involved the use of a stratified sample, the theory could only be tested in a very limited way in this study. According to the theory, however, only one factor is predicted on a bipolar continuum from consistent Function choices to consistent Form choices. This statement implies that the set of F-F Preference Test items in which the choice is always and only between Form (shape and visual similarity) and Function (belonging together because of some meaningful relationship and not similar appearance) would be a homogeneous set of items. This homogeneity was tested by a measure of interitem consistency. A third way of checking the structural component of validity was to compare the attractiveness of the sets of Form and Function pairs.

Reliability

Reliability is a major consideration in evaluating the psychometric characteristics of a test or scale. Two methods of estimating reliability have been used in this study: **Test-retest** reliability as a measure of stability and Cronbach's alpha as a measure of internal consistency.

1. **Stability.** Since the 5 and 6 year olds are in their first year in school and are very much affected by every month of teaching and maturation, a group of 7, 9 and 11 year olds were retested after an intervening period of four weeks enabling the calculation of a stability coefficient.

2. **Internal Consistency.** Internal consistency was estimated through the use of Cronbach's coefficient **alpha** which in dichotomously scored tests is equivalent to K-R 20. This method for finding reliability uses a single administration of a single form of a test and is based on the consistency of responses to all items in the test. For purposes of calculating the reliability coefficient for the F-F Preference Test, all the subjects' responses were considered.

Attractiveness of Pairs of Stimuli

To determine whether or not there is a differential in attraction between pairs of items, each person in a graduate measurement class was asked to sort the pairs of stimuli (both Form and Functional pairs, e.g., orange-ball and orange-banana) onto a 9-point "strength of association" continuum, with 1 representing no association and 9 an extremely strong association.

After the sorting data were collected, scale scores were determined for each pair by using equal appearing intervals and also by Thurstone's law of categorical judgement (Thurstone, 1927; Torgerson, 1958). The results were graphed and one could see that, while the spread was greater for the Function pairs, the distribution of the Form matches was interspersed among the upper two-thirds of the distribution of Function pairs (see Table 3-3). The items rating the lowest among the graduate students were the relational associations which are more appealing to younger children. The conclusion was that there was no need for a differential weighting of F-F Preference Test items because of attractiveness.

Table 3-3: Matched stimuli ordered by strength association from strongest to weakest

Order[1]	Match	Item	Order	Match	Item
1	Function	Banana-Banana	15	Function	Orange-Banana
2	Function	Snake-Snake	16	Function	Bird-Bird
3	Function	Book-Book	17	Form	Hat-Round Cake
4	Form	Broom-Rake	18	Form	Nest-Basket
5	Form	Rope-Snake	19	Function	Hat-Hat
6	Function	Broom-Broom	20	Function	Snake-Lizard
7	Form	Rope-Hose	21	Form	Square Cake-Book
8	Form	Banana-Moon	22	Function	Moon-Stars
9	Function	Rake-Rake	23	Function	Nest-Birdhouse
10	Form	Orange-Ball	24	Function	Knife- Scissors
11	Form	Bird-Gloves	25	Function	Bird-Nest
12	Function	Cake-Cake	26	Function	Hose-Watering Can
13	Function	Hose-Hose	27	Function	Round Cake-Knife
14	Form	Scissors-Fork&Spoon	28	Function	Square Cake-Knife

[1] Order: scale score determined by equal appearing intervals and categorical judgement

Factor Analyses

According to theories of cognitive processing, only one factor was predicted on a bipolar continum from consistent Function choices to consistent Form choices. Because the conceptual choices come in four classes (see Table 3-2), there was a possibility of more than one factor appearing. Thus two different factor analyses were conducted: one with F-F test items plus dummy items and one with only the test items. In the former analysis, it was predicted that the test items would load on only one factor while the dummy items load on others. In the analysis of test items only, the structure was predicted to be unifactorial, or to have one factor which would be very much stronger than the others. The factor model adopted for use in this study was Joreskog's Confirmatory Maximimum Likelihood Factor Analysis (Joreskog & Van Thillo, 1971) where specific hypotheses regarding the nature of the factors can be tested. If the optimum number of factors appeared to be greater than one, then the factor structure of different groups would be compared.

Summary

The structural component of validity was tested in the following ways:

1. Through estimation of the internal consistency of the scores on the F-F Preference Test.

2. Through ordering the items by strength of association to establish that there is no great difference in drawing power between the Form and the Function items.

3. Through factor analysis to determine whether or not the factor structure supports the theory of Cognitive Processing Bias as a single bipolar factor.

C. The External Component

The external component has traditionally been taken to mean the correlation of a test with an external criterion of what it is supposed to measure. More recently it hes been evaluated in terms of the complete patterns of its correlations in the light of the nomological network of theoretical predictions (Cronbach & Meehl, 1955). The nomological network for this study is portrayed in Fig. 3-5. In relating empirical observations to theoretical constructs, one must assume that the first set of tests (Wechsler Similarities and Vocabulary) measure Verbal-Analytical processing and that the second set of tests (Wechsler Block Design and Object Assembly) measure skills in Spatial-Holistic processing. The justification for the use of these tests is presented above.

The main task, therefore, was to demonstrate empirically that a bias on the F-F Preference Test would predict an imbalance between S-H and V-A processing skill levels. To this end, subjects were tested for a S-H/V-A cognitive mode imbalance. Of the four Wechsler subtests used, three appear in both the WPPSI and WISC-R but the WISC version of Object Assembly had to be used for 5-6 year olds. Since the Wechsler subtests have been well normed for ages 5 to adult, results should be comparable across age groups. Subjects were classified as having Stronger S-H skills, Equal skills, or Stronger V-A skills by using a criterion of a difference between S-H and V-A totals of twice the standard error of measurement of the tests.

The factor structures of the items of the F-F Preference Test were compared for the youngest group (age 5), a middle group (ages 6, 7 & 9), and the oldest group (age 11). Correlational analyses were then used to determine which items of the F-F Preference Test are the best predictors of Cognitive Balance &/or Reading Achievement at each age.

Because of the research design involving five levels of Age, three Cognitive Balance groups and two levels of Reading Achievement, a total of 30 cells was involved for this part of the study. An attempt was made to find at least 10 subjects per cell with an acceptable minimum set at 5 subjects per cell. Analyses of variance of the total F-F Preference Test scores were calculated for the effects of Age, Cognitive Balance and Reading Achievement. Post hoc comparisons were

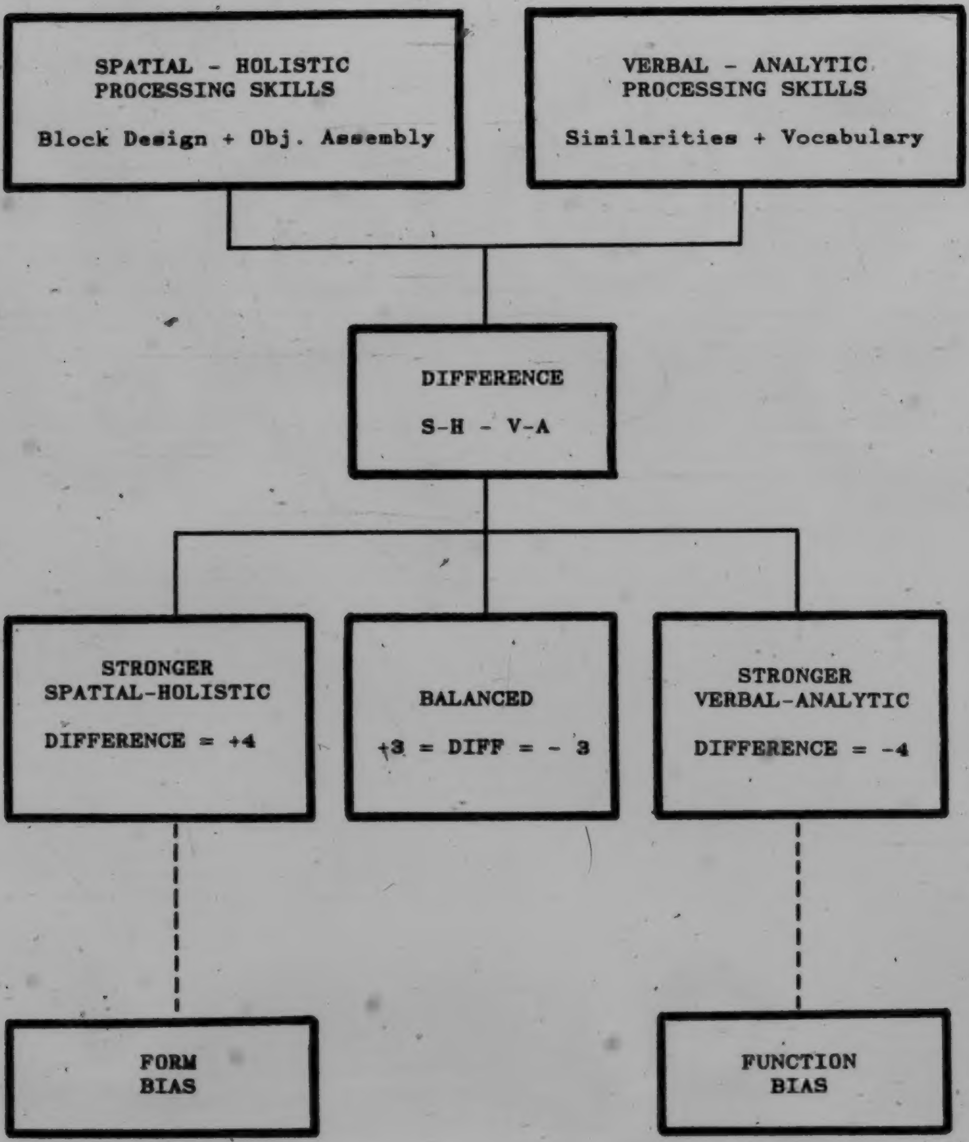

SPATIAL - HOLISTIC
PROCESSING SKILLS
Block Design + Obj. Assembly
VERBAL - ANALYTIC
PROCESSING SKILLS
Similarities + Vocabulary
DIFFERENCE
S-H - V-A
STRONGER
SPATIAL-HOLISTIC
DIFFERENCE = +4
BALANCED
+3 = DIFF = - 3
STRONGER
VERBAL-ANALYTIC
DIFFERENCE = -4
FORM
BIAS
FUNCTION
BIAS

Figure 3-5: Nomological Network: Basis for the F-F Preference Test

conducted using the Tukey-Kramer test which is intended to be used in designs with homogeneity of variance but unequal cell sizes.

The form of the Tukey-Kramer test is:

$$\left[\bar{X}_i - \bar{X}_j\right] \left[\sqrt{MSe\ (1/n_i + 1/n_j/2}\right]$$

where n_i and n_j are the n's associated with the two means, $\bar{X}_i$ and $\bar{X}_j$.

MSe is the error mean square from the analysis of variance.

The critical value is the same as for Tukey's HSD and can be looked up in a Studentized Range Distribution Table.

Because this study is a form of exploratory research, and because of the small number in each cell it is important to examine the data from the extreme groups closely. Results are presented to the reader numerically for verbal-analytic processing and graphically for spatial-holistic processing.

SUMMARY OF CONSTRUCT VALIDITY

The traditional way of establishing construct validity is to test the theory and the new test by using well known measures to corroborate them. In this study, the theory has been shown to have a solid base in the empirical studies of hemispheric asymmetry. The test has been developed according to Loevinger's model, keeping the items consistent with the theory and using a phenomenological approach during the substantive steps. The substantive component of validity has been further demonstrated through item analyses, both by judges and by computer analyses. The structural component has been estimated in three main ways: by comparing the strength of association of the Form and Function items, by determining the factor structure of the responses to the test, and by estimating the reliability of the test through measures of internal consistency and stability.

The external component has been validated through the use of two tests judged to measure Verbal-Analytic processing and two judged to measure Spatial-Holistic processing. Validity of the theory has been tested using the Wechsler subtests to determine whether some children appear to show an imbalance in their cognitive processing.The V-A and S-H tests were used to separate the subjects into Balance groups. F-F Preference Test items were analysed for their ability to predict Balance and Reading Achievement and the factor structures were compared for three age groups. Total scores were then analysed to compare the effects of Age, Cognitive Balance and Reading Achievement. After the analyses of variance were conducted, the Tukey-Kramer statistic was used for post hoc comparisons to test the significant interactions. Finally, possible tendencies toward group differences were explored.

4. RESULTS

The results of this study will be presented in five sections. The first section will summarize the characteristics of the sample. Next the relationships among Age, Cognitive Balance, Reading Achievement and Wechsler Test Scores will be discussed. The third section will examine the structural component including item analyses and estimation of internal consistency. The fourth section will summarize the analyses of the external component -- the relationships among F-F Test scores and Cognitive Processing Balance, Age, and Reading Achievement. The last section will examine differences in F-F Test results of each cell.

CHARACTERISTICS OF THE SAMPLE

The sample was divided into 30 cells according to Age, Cognitive Balance and Reading Achievement. The chronological age, gender and I.Q. characteristics of the subjects in each cell, presented in Table 4-1, show the similarity of the cells on these variables. This table also includes the mean totals for each group on the two Verbal-Analytic tests and the two Spatial-Holistic tests, thus demonstating the differences among Cognitive Processing Balances Groups and Reading Groups.

RELATIONSHIPS AMONG INDEPENDENT VARIABLES AND WECHSLER TEST SCORES

In this section, the relationships among Cognitive Processing Balance, Age, Reading Achievement and Wechsler Subtest Scores will be examined as an important preliminary check on the sample to ensure that these have not become intervening variables. Since Age, Balance Group and Reading Group have been fixed and an attempt has been made to equalize the numbers in each cell, only the Wechsler Test Scores have been free to vary. It is important that IQ not be confounded with Age and Cognitive Balance but IQ should be confounded with Reading Achievement. Cognitive Balance, Age and Reading groups were, therefore, compared on extrapo-

Table 4-1: Characteristics of the sample: Means and standard deviations of the fixed groups on demographic variables

Age Grp.	Read. Ach. Grp.	Cog. Bal. Grp.	Sex F	Sex M	Age Range (months)	Extrapolated I.Q. Mean	Extrapolated I.Q. S.D.	Verbal-Anal. Total Mean	Verbal-Anal. Total S.D.	Spatial-Hol. Total Mean	Spatial-Hol. Total S.D.	Reading Achievement Decod	Reading Achievement Comp.
5	Good	V-A	4	4	65 - 74	124.4	13.97	29.8	4.13	23.6	3.50	-	-
		Equ.	5	4	66 - 71	119.4	11.94	25.1	3.37	25.6	3.47	-	-
		S-H	4	4	66 - 71	125.3	9.07	24.1	2.59	29.9	2.64	-	-
	Poor	V-A	4	6	64 - 76	109.9	10.92	26.4	2.76	20.2	2.50	-	-
		Equ.	3	2	65 - 71	111.2	5.81	24.0	2.12	22.4	1.58	-	-
		S-H	2	5	64 - 70	113.1	14.47	19.9	4.74	27.4	3.74	-	-
6	Good	V-A	4	5	76 - 86	119.4	11.05	28.8	2.82	22.2	3.15	48-81	55-84
		Equ.	5	4	77 - 86	114.6	11.30	24.0	3.35	24.0	4.00	64-87	49-73
		S-H	5	4	78 - 83	115.7	15.03	20.8	4.24	27.7	4.12	53-85	47-86
	Poor	V-A	3	6	78 - 83	108.2	8.96	25.3	2.35	19.4	2.60	21-30	28-35
		Equ.	4	5	77 - 83	99.3	8.60	19.9	2.26	20.1	3.06	3-28	4-31
		S-H	2	5	76 - 86	101.0	10.13	17.1	3.24	23.6	3.10	6-28	12-46
7	Good	V-A	4	4	89 - 95	124.4	18.60	29.4	5.12	22.8	4.13	50-88	81-91
		Equ.	3	6	90 - 98	118.2	18.49	25.2	5.56	25.3	4.69	3[illegible]-88	55-96
		S-H	2	3	91 - 96	121.2	21.78	22.8	6.22	29.2	5.40	50-74	50-81
	Poor	V-A	5	4	90 - 96	109.1	14.93	25.4	4.59	19.4	3.21	11-30	18-65
		Equ.	2	7	88 - 94	110.2	12.66	22.9	4.54	23.2	3.42	9-30	6-71
		S-H	5	2	90 - 95	101.7	10.72	18.1	3.08	23.1	2.85	-	-
9	Good	V-A	2	5	112 - 124	111.0	8.94	26.7	3.55	20.9	2.67	60-79	56-87
		Equ.	5	3	114 - 119	115.0	21.21	24.3	5.87	23.8	6.11	51-98	43-95
		S-H	3	3	114 - 122	124.8	9.00	23.3	2.42	30.3	2.81	48-95	33-99
	Poor	V-A	3	3	113 - 123	109.2	6.74	25.2	2.14	20.0	1.41	4-33	10-23
		Equ.	4	2	113 - 119	104.7	11.55	22.0	2.97	20.8	3.76	30-65	20-26
		S-H	1	8	113 - 122	106.7	13.51	18.4	4.10	25.2	3.63	4-30	24-77
11	Good	V-A	3	6	137 - 146	118.2	12.70	28.1	2.85	22.0	4.47	55-97	43-99
		Equ.	3	6	141 - 146	118.3	12.03	25.2	3.67	24.8	2.95	31-87	51-97
		S-H	5	4	136 - 147	122.1	13.71	22.7	3.91	29.4	3.68	55-94	59-97
	Poor	V-A	1	6	138 - 145	108.7	10.37	25.3	2.69	18.3	3.35	-	-
		Equ.	3	6	135 - 143	105.1	9.49	21.3	1.80	21.8	3.60	6-47	11-47
		S-H	7	2	135 - 143	105.4	4.75	17.7	2.50	25.8	1.56	1-42	1-32

lated IQ scores. Analyses of variance were conducted to estimate the effects (see Table 4-2). The results will be discussed in the context of each independent variable.

Table 4-2: Summary ANOVA Table: Effects of Age, Balance and Reading on IQ scores

Source of Variability	Sum of Squares	df	Mean Square	F-Ratio	Prob.
Age	1404.40	4	351.10	2.18	0.073
Balance	345.45	2	172.73	1.07	0.345
Rdng Ach.	9442.93	1	9442.93	58.51	0.000
Age x Bal	803.18	8	100.40	0.62	0.759
Age x Rdng	101.10	4	25.28	0.16	0.960
Bal x Rdng	334.25	2	167.12	1.04	0.357
Residual	33894.24	210	161.40		

Cognitive Processing Balance

By definition, the Stronger Verbal-Analytic Group has a negative Difference Score of at least four points and the Stronger Spatial-Holistic Group has a positive Difference Score of at least four points. The Equal Group has been set to vary from -3 to +3. Mean Difference Scores for each group at each age are shown in Table 4-3.

Table 4-3: Mean Difference Scores: Cognitive Balance by Age

	Stronger	S-H	Equal		Stronger	V-A
Age	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	6.60	2.35	0.33	1.14	-6.16	1.57
6	6.81	2.66	0.40	2.28	-6.15	1.69
7	5.58	1.62	0.22	1.47	-6.41	1.62
9	6.59	2.21	0.36	1.86	-5.43	2.38
11	7.80	2.95	-0.13	2.12	-6.50	3.76

To ascertain whether there were important differences in intellectual skill level between the Balance groups, the estimated IQ's were compared (see Table 4-1 for the means and standard deviations and 4-2 for the ANOVA). No significant effects were found for Cognitive Processing Balance.

Age

The means at each age level for the Spatial-Holistic Total (Block Design Scaled Score + Object Assembly Scaled Score), the Verbal-Analytic Total (Vocabulary Scaled Score + Information Scaled Score) and extrapolated IQ score were presented in Table 4-1 above, Analyses of Variance for IQ shown in Table 4-2. There was no significant effect of age for S-H Total (F = 1.21), V-A Total (F = 1.96) or Difference Score (F = 0.98), but since the effect of IQ was almost significant (F = 2.18, P = .07), the Wechsler subtest results were not collapsed over age in analysing subgroups of the sample.

Reading Achievement

The 5 year old "Good" Group was comprised of those who were clearly ready to learn to read (teacher's evaluation) and the "Poor" of those 5 year olds whom the teacher felt were not yet ready (see group criteria in Chpt.3). The 6 to 11 year old Good Reading groups were defined by a criterion by which they must be at or above the 50th percentile on both the Decoding and Comprehension subtests of the Edmonton Public School Board or the Canadian Test of Basic Skills if such scores were available, and/or by teacher evaluation. The 6 to 11 year old Poor Reading Groups were made up of children below the 30th percentile on one of the reading tests, in a special class or children who had repeated a grade. The Decoding and Comprehension Scores are presented in Table 4-1 for children tested with the EPBS or CTBS Reading Tests.

Good and Poor Readers were represented in similar numbers in the study at each level of Age and, with considerable effort by the researcher, at each level of

Cognitive Balance. The search for Stronger S-H Good Readers at ages 7 & 9, and Stronger V-A Poor Readers at ages 9 & 11 may have produced Type II Error in the study.

It was important to estimate the strength of the difference in IQ between the Good and Poor Reading groups. Across ages, the correlation between I.Q. and Reading Achievement was 0.44, with the correlation at age 5 = 0.47, age 6 = 0.53, age 7 = 0.40, age 9 = 0.35, and age 11 = 0.54. When the extrapolated IQ scores were analysed, the expected strong significant main effect of Reading Achievement appeared but no other significant differences (see Table 4-2).

Difference scores in this study have been governed by the research design which involved a search for equal numbers of Good and Poor Readers in each Balance Group -- thus, the Difference Scores are similar in each Reading Group. As can be be seen from the means in Table 4-1, however, Good Readers are higher on the Wechsler subtests at each age than Poor Readers. Within the groups of Good and Poor Readers there is no significant difference between S-H Total and V-A Total (t = -0.42) -- they do no better on the spatial tests than on the verbal ones. The sample, then, is balanced between and within Reading Achievement groups at all levels of Age and Cognitive Processing Balance.

STRUCTURAL COMPONENT OF VALIDATION

Concern here is focused on the internal consistency or homogeneity of the scale. The first step in analyzing the data was to conduct several different kinds of item analyses: first, to look for ambiguous items, second, to estimate the internal consistency of the test and, third, to estimate the factor structure of the test.

Subjects' Interpretations

While the F-F Test was being administered, each child was asked for reasons for making some of their choices and to name all the pictures to check that they were identified properly. The witch's broom in item #22 was occasionally called a mop instead of a broom disqualifying that picture as a nominal match for the push broom. Inconsistencies were noted in several explanations where the child made what was ostensibly a Function choice of rake-rake but gave a Form reason: "they both have points here." For items #9, 20, and 40, several children chose the hat-cake Form match but said, "they are both for a party." Thus in the final analyses and revision of the F-F Test, items #22, #9, #20, and #40 were eliminated resulting in a test with 16 F-F items and 19 distractors.

Reliability

Reliability of the F-F Test was estimated through measures of internal consistency and stability.

Internal Consistency

Item analyses of the final 16-item F-F Test were conducted using Division of Educational Research Services, University of Alberta, computer progam called TEST18. As presented in Chapter 3 above, internal consistency coefficients, Cronbach's Alpha, were calculated for the total sample of 240 subjects and separately for each age group. The alpha for the total sample was calculated to be 0.958; for age 5, 0.748; 6, 0.834; 7, 0.803; 9, 0.915; and 11, 0.904. Since the lowest value at any age was 0.748 the internal consistency of the F-F Test was considered to be adequate.

Stability

The F-F Test was administered on two occasions 4 weeks apart to 68 children aged 7, 9 and 11 years. The correlation between the two sets of scores for the total group was 0.791. Correlations between time 1 and time 2 for the age groups were as follows: age 7, n = 27, r = 0.481; age 9, n = 20, r = 0.918; age 11, n = 21, r = 0.892. While the stability is barely adequate for the 7 year olds, it is excellent for 9 and 11 year olds.

Factor Analyses

The factor structure of the F-F Test was estimated analysing **Items**, which were scored as Form or Function responses, and **Distractors** (placed randomly in the F-F Test to distract the subjects from the researcher's purpose for the test), which were scored as Right or Left choices. Using Joreskog's model of Maximum Likelihood Factor Analysis and a criterion of eigenvalues $\geq$1.0, a total of 11 factors were extracted. Eigenvalues and the percent of total variance explained by these factors are presented in Table 4-4. The varimax rotated factor matrix is shown in Table 4-5 with Items and Distractors sorted separately according to size of loading on the first factor (only those loadings greater than 0.30 are shown to simplify the picture of the pattern). Complete results are shown in Appendix B, Table II-1).

Table 4-4: Eigenvalues of the 11-factor model: F-F Test Items plus Distractors

Factor	Eigenvalue	Percent of Total Variance
1	6.01	17.2
2	2.09	6.0
3	1.79	5.1
4	1.48	4.2
5	1.45	4.1
6	1.32	3.8
7	1.30	3.7
8	1.20	3.4
9	1.13	3.2
10	1.11	3.2
11	1.07	3.0

One can see clearly the presence of two strong factors consisting only of F-F Test Items with two single loadings of Distractors. There are only three Item loadings on factors which portray the Distractors. Thus, it is quite clear that the Items occupy a different factor space than do the distractors. The items having their strongest loading on Factor 1 are all Relational Items with one exception; those having their strongest loading on Factor 2 are all Nominal (two relational items have their strongest loadings on Factors 4 & 5). One would thus be justified in labelling the first factor one of Relational Items and the second Nominal Items. While the hypothesized single bipolar factor failed to materialize, the second hypothesis that two item factors sorted by functional category (Nominal & Relational) can partially be upheld. Nevertheless, the crucial evidence relating to structural validity is that the test items load on one pair of factors and the distractors on several others. As will be seen in the section on external validity, the factor structure is different for different age groups.

EXTERNAL COMPONENT OF VALIDATION

The external component of validity testing consisted of analysing the ability of the F-F Test to predict independent variables. First, the effectiveness of the F-F Test in differentiating among the groups divided according to Age, Cognitive Balance and Reading Achievement was estimated. Secondly, The F-F Test items were examined individually to estimate the effect of the independent variables in terms of the frequency of Form/Function responses in each group, correlations between Form/Function responses and the independent variables, and, finally, the factor patterns of the item responses for each group.

Table 4-5: Rotated factor matrix comparing Form responses to F-F Test Items with Right-Left responses to Distractors

	FACTORS										
	1	2	3	4	5	6	7	8	9	10	11
Item #											
I# 5		54									
I# 7		66									
I#11	37	51									
I#13		59									
I#14	32	46		48							
I#16	37	66									
I#18	53	34									
I#23	36				51						
I#25	69										
I#26	70										
I#28	67										
I#30	59										
I#31	53				38						
I#33	63										
I#35	62										
I#36	61										
Distractor #											
D# 1			46	32							
D# 2										-68	
D# 3						-38		-38			
D# 4											82
D# 5						-34				51	
D# 6								73			
D# 7									73		
D# 8			78								
D# 9										40	-44
D#10		48									
D#11						75					
D#12					68						
D#13	38										
D#14							77				
D#15							58				
D#16			80								
D#17					-33	44					
D#18								40	49		
D#19				73							

Group Differences on F-F Test Scores

The independent variables investigated in the study for their effect on the F-F Test total scores are Cognitive Balance, Age, and Reading Achievement. A three-way Analysis of Variance was conducted to estimate main effects and interactions. Means and standard deviations of Form choices by each Cognitive Balance group at each level of Age are presented in Table 4-7 (graphed in Figure 4-1), and means of each Reading group at each level of Age and at each level of Balance in Table 4-7 (Figure 4-2, 4-3, 4-4). The Summary ANOVA table appears in Table 4-8. The effects of Cognitive Balance and Reading on the F-F Test scores are not significant but there is a significant main effect of Age. The two-way interaction between Age and Reading Achievement is also significant.

Effect of Cognitive Processing Balance on F-F Test Scores

As can be seen in Table 4-8, there was no significant main effect of Cognitive Processing Balance on F-F Test scores. Neither was there a significant interaction between Cognitive Processing Balance and either Age or Reading Achievement.

Effect of Age on F-F Test Scores

The main effect of Age on F-F Test scores was highly significant (F = 11.77). Tukey-Kramer Tests indicated that subjects age 5 made significantly fewer Form choices than ages 6, 7 or 9 (5.85, 6.61, and 5.15, respectively); similarly, a comparison of age 11 versus 6, 7, and 9 produced test statistics of 6.32, 7.08, and 5.57, respectively.

Examination of the F-F Test means at each age showed the effect of age to be strongly curvilinear. It was possible to use equal intervals while examining the nature of the curvilinear effect of age since the curve was relatively smooth. Age 6 was, therefore, excluded from the analyses of variance in which the linear and quadratic functions were tested for significance. It was clear from these analyses

Table 4-6: Means and standard deviations of Form choices on F-F Test: Age by Cognitive Balance

Age		n	Mean	Std Dev
5		47	7.47	3.41
	V-A	18	8.22	3.99
	Equal	14	7.86	3.08
	S-H	15	6.20	2.73
6		52	10.88	3.81
	V-A	18	10.56	4.60
	Equal	18	10.67	3.87
	S-H	16	11.50	2.78
7		47	11.43	3.55
	V-A	17	10.82	4.19
	Equal	18	11.61	2.87
	S-H	12	12.00	3.67
9		42	10.64	4.94
	V-A	13	12.00	4.60
	Equal	14	8.29	5.66
	S-H	15	11.67	3.89
11		52	7.29	5.08
	V-A	16	6.50	5.42
	Equal	18	6.44	5.06
	S-H	18	8.83	4.69

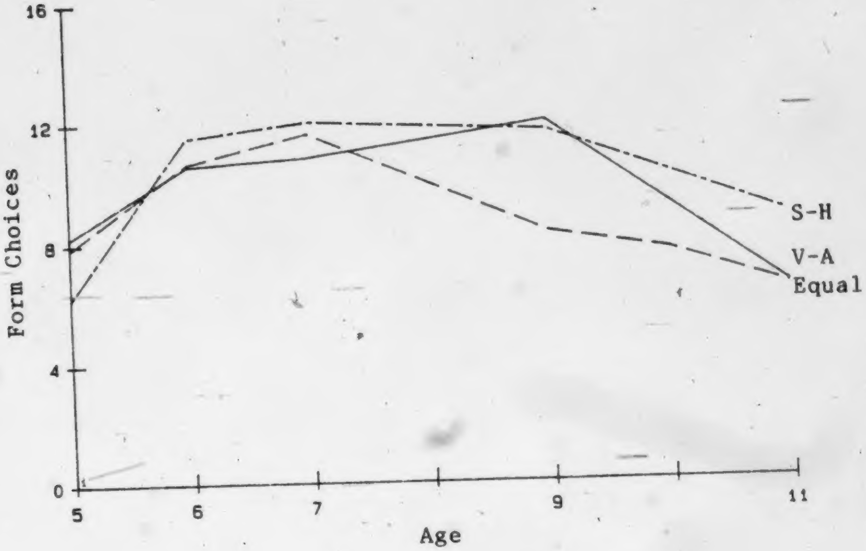


Figure 4-1: Effect of Balance on F-F Test means at each Age

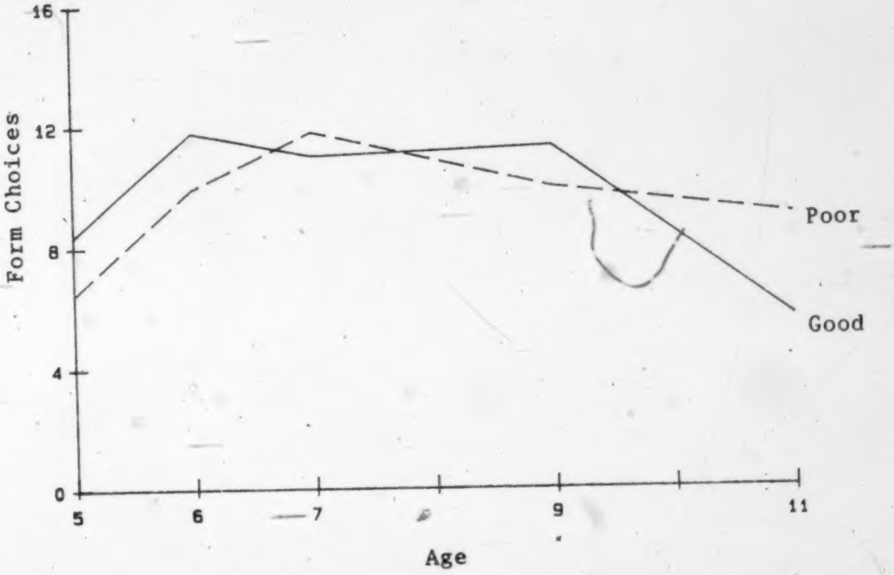


Figure 4-2: Effect of Reading on F-F Test means at each Age

Table 4-7: Means & standard deviations of Form choices on F-F Test for each Balance, Age and Reading Group

Age	Reading	Balance	n	Mean	Std Dev
5	Good		25	8.36	3.85
		V-A	8	10.50	4.38
		Equal	9	8.22	2.86
		S-H	8	6.38	3.54
	Poor		22	6.45	2.56
		V-A	10	6.40	2.63
		Equal	5	7.20	3.70
		S-H	7	6.00	1.63
6	Good		27	11.78	3.49
		V-A	9	11.67	3.60
		Equal	9	11.89	4.37
		S-H	9	11.78	2.73
	Poor		25	9.92	3.97
		V-A	9	9.44	5.41
		Equal	9	9.44	3.05
		S-H	7	11.14	3.02
7	Good		22	11.00	3.56
		V-A	8	11.50	4.34
		Equal	9	10.78	2.64
		S-H	5	10.60	4.33
	Poor		25	11.80	3.57
		V-A	9	10.22	4.20
		Equal	9	12.44	3.00
		S-H	7	13.00	3.06
9	Good		21	11.33	4.53
		V-A	7	12.43	5.41
		Equal	8	9.75	4.89
		S-H	6	12.17	2.64
	Poor		21	9.95	5.33
		V-A	6	11.50	3.89
		Equal	6	6.33	6.47
		S-H	9	11.33	4.66
11	Good		27	5.67	4.09
		V-A	9	4.78	3.93
		Equal	9	5.89	4.88
		S-H	9	6.33	3.67
	Poor		25	9.04	5.53
		V-A	7	8.71	6.52
		Equal	9	7.00	5.45
		S-H	9	11.33	4.39

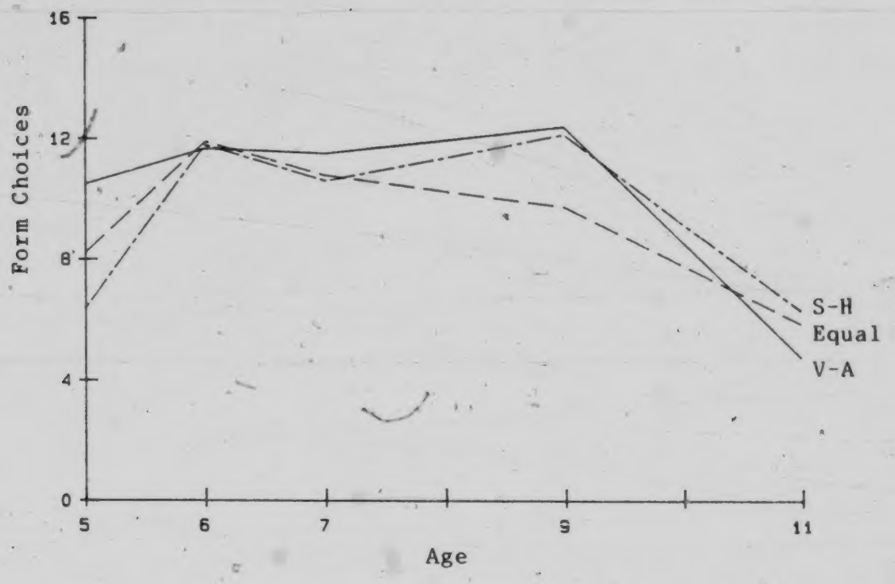


Figure 4-3: Good Readers' F-F Test means: Cognitive Balance by Age

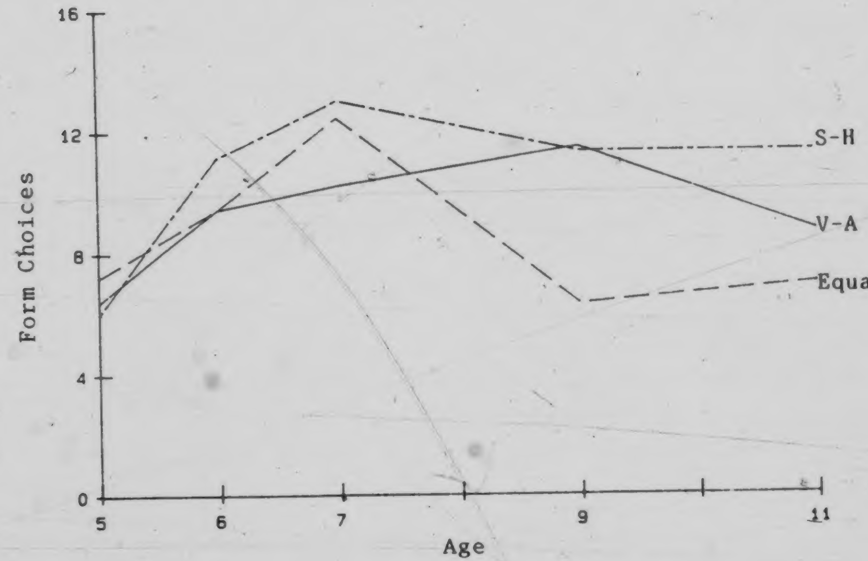


Figure 4-8: Proportion of Poor Readers with Form Bias: Balance by Age

Table 4-8: Summary ANOVA table estimating effects of Balance, Age and Reading on F-F Test Scores

Source of Variability	df	Sum of Squares	Mean Square	F-Ratio	Prob
Cognitive Balance	2	45.84	22.92	1.36	0.26
Age	4	793.66	198.42	11.77	0.00**
Reading	1	1.68	1.68	0.10	0.75
Balance x Age	8	193.07	24.13	1.43	0.19
Balance x Rdng	2	54.47	27.23	1.62	0.20
Age x Rdng	4	265.48	66.37	3.94	0.00**
Bal x Age x Rdng	8	66.08	8.26	0.49	0.86
Residual	210	3539.66	16.86		
Total	239	4948.00	20.70		

that the linear term was not significant, that the quadratic term was highly significant and that there was no significant term in the polynomial beyond the quadratic (see Table 4-9).

Effect of Reading Achievement on F-F Test Scores

While the main effect of Reading Achievement on F-F Test Scores was not significant, there was a significant interaction between Reading Achievement and Age (F=3.94). It was not clear, however, whether this effect was caused by Reading Achievement alone or by a difference in intelligence test scores which were found to be significantly correlated with Reading Achievement (r = 0.44 across age, 0.47 at age 5, 0.53 at age 6, 0.40 at age 7, 0.35 at age 9, and 0.54 at age 11). The variance in F-F Test scores was reanalyzed, therefore, using IQ as a covariant (see Table 4-10). Since none of the effects changed significantly, IQ can be discounted as an intervening variable.

Table 4-9: Summary ANOVA table examining the linearity of the effect of Age on F-F Test scores

Source of Variability	df	Sum of Squares	Mean Square	F-Ratio	Prob
Between Groups	3	692.75	230.92	12.21	0.00
Linear Term	1	27.39	27.39	1.44	0.23
Dev'n from Lin.	2	665.36	332.68	17.59	0.00
Quadratic Term	1	664.20	664.20	35.13	0.00
Dev'n from Quad.	1	1.16	1.16	0.06	0.81
Within Groups	197	3725.13	18.91		

Table 4-10: Summary ANCOVA table: F-F Test scores analyzed for effects of three fixed factors covaried with IQ

Source of Variability	df	Sum of Squares	Mean Square	F-Ratio	Prob
Covariate (IQ)	1	23.85	23.85	1.41	0.24
Cognitive Balance	2	48.91	24.45	1.45	0.24
Age	4	768.38	192.10	11.36	0.00
Reading	1	6.88	6.88	0.41	0.52
Balance x Age	8	191.35	23.92	1.42	0.19
Balance x Reading	2	51.60	25.80	1.53	0.22
Age x Reading	4	264.11	66.03	3.91	0.00
Residual	209	3533.43	16.91		
Total	239	4946.00	20.70		

F-F Test: Interaction between Age and Reading Achievement

The main effect of age showed that 5 year olds and 11 year olds made significantly fewer Form choices than did 6, 7 & 9 year olds. Tukey-Kramer tests of differences between levels of Age at each level of Reading show that Poor Readers contribute most to the difference between 5 & 7 year olds (6.30), while Good Readers contribute most to the differences between 11 year olds and 6, 7 & 9 year olds (7.73, 6.40 & 6.71). The only significant difference between Reading Groups at each level of Age is between Good and Poor Readers at Age 11 (4.19).

Frequency Comparison: Proportion of Form Bias in each Group

Categorizing the subjects into Form Bias (F-F Test score 9 to 16) and Function Bias (F-F Test score 0 to 8) does not change the overall patterns but does show some of the differences more clearly (see Table 4-11, 4-12 and Figure 4-5, 4-6, 4-7 & 4-8). At ages 5 and 11, only about 40% of the subjects show a Form Bias while 70% of 6 - 9 year olds do. Five year olds in the S-H group (with weaker Verbal-Analytic skills) look very different from the other two 5 year old groups. Those who were deemed "ready to learn to read" and whose Verbal-Analytic skills were equal to or better than their Spatial-Holistic skills (Table 4-12, Good V-A and Good Equal) looked more like 6 year olds with 11/17 (65%) showing a Form Bias, while only 5/30 (17%) of the other five year olds showed a Form Bias.

The S-H group increased their proportion of Form Bias greatly from age 5 to age 6, however: 1/15 (7%) at five to 14/16 (88%) at six. Among 6 - 9 year olds, overall 99/141 (70%) showed a Form Bias, but Poor Readers in the Equal group had only 13/24 (54%) with a Form Bias. While 19/27 (70%) of 11 year old Good Readers have switched to a Function Bias leaving only 30% still showing a Form Bias, 14/25 (58%) of 11 year old Poor Readers still prefer Form. Within the specialized group of 11 year old S-H Poor Readers, the differences are even more extreme with 7/9 (78%) still showing a Form Bias. Thus, there has been a transition from a strong preference for Form at ages 6 to 9 to a preference for Function among Good Readers at Age 11 with the Spatial-Holistic Poor Readers being left farthest behind. It is important to extend the study with a larger sample to higher ages as important differences among Balance Groups seem likely to appear within Age and Reading Groups.

Group Differences on F-F Test Items

The F-F Test Items were analysed for the effects of the same independent variables as were the total scores: Age, Cognitive Processing Balance and Reading Achievement. Frequencies of Form/Function responses were examined first, next, correlations between the responses and the independent variables and, finally, the factor patterns of the responses for various groups were compared.

Table 4-11: Proportions of Form Bias: Age by Balance and Reading

GROUP			A G E		
	5	6	7	9	11
Balance					
V-A	8/18 44.4%	12/18 66.7%	11/17 64.7%	9/13 69.2%	7/16 43.8%
Equal	7/14 50.0%	11/18 61.1%	14/18 77.8%	7/14 50.0%	6/18 33.3%
S-H	1/15 6.7%	14/16 87.5%	10/12 83.3%	13/15 86.7%	9/18 50.0%
Reading					
Good	12/25 48.0%	22/27 81.5%	16/22 72.7%	16/21 76.2%	8/27 29.6%
Poor	4/22 18.2%	15/25 60.0%	19/25 76.0%	13/21 62.0%	14/25 56.0%

Table 4-12: Proportions of Form Bias: Age by Reading by Balance

GROUP				AGE		
Reading	Balance	5	6	7	9	11
GOOD	V-A	6/8	7/9	6/8	5/7	3/9
	Equal	5/9	7/9	7/9	5/8	3/9
	S-H	1/8	8/9	3/5	6/6	2/9
POOR	V-A	2/10	5/9	5/9	4/6	4/7
	Equal	2/5	4/9	7/9	2/6	3/9
	S-H	0/7	6/7	7/7	7/9	7/9

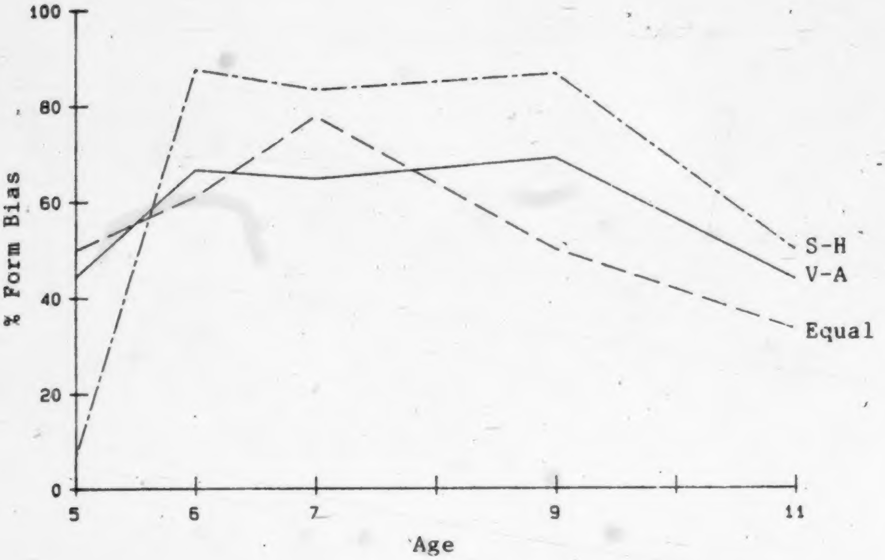


Figure 4-5: Proportion of Balance Groups with Form Bias at each Age

Figure 4-5: Proportion of Balance Groups with Form Bias at each Age

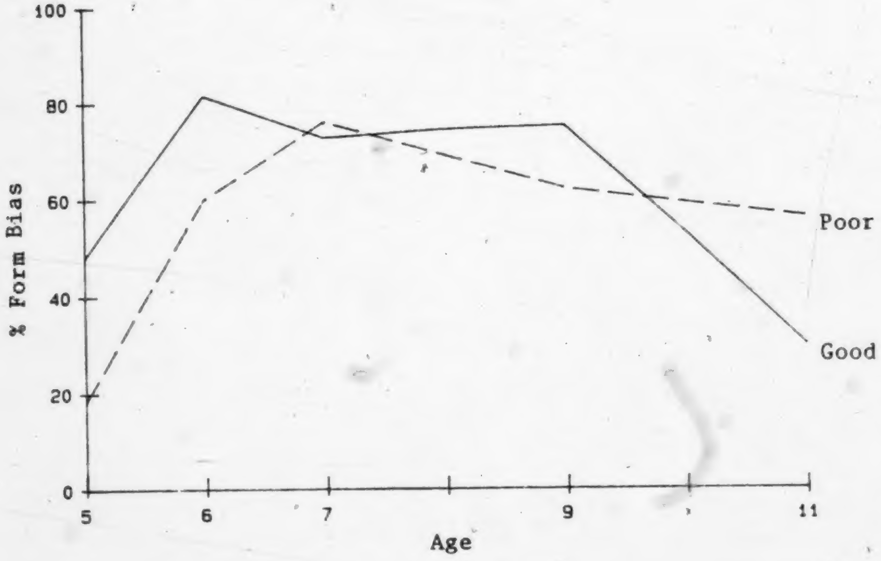


Figure 4-6: Proportion of Reading Groups with Form Bias at each Age

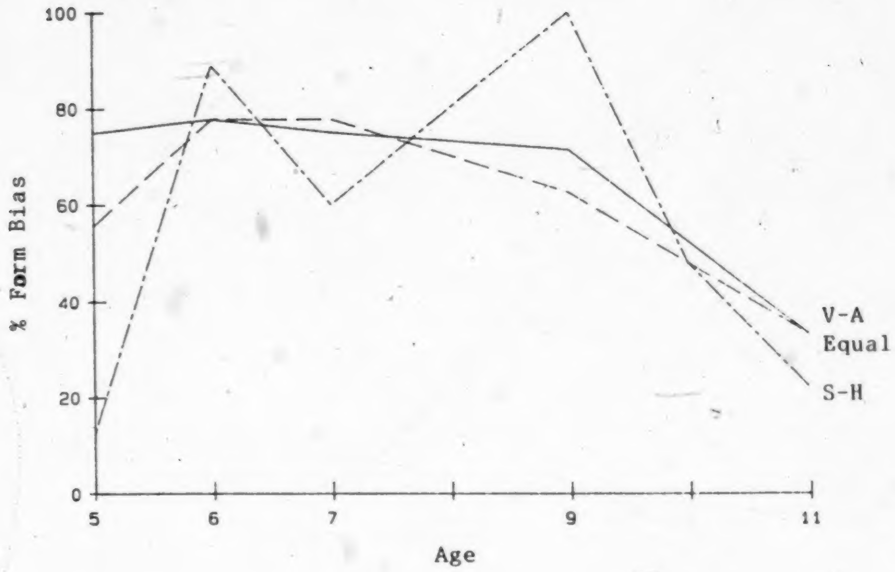


Figure 4-7: Proportion of Good Readers with Form Bias: Balance by Age

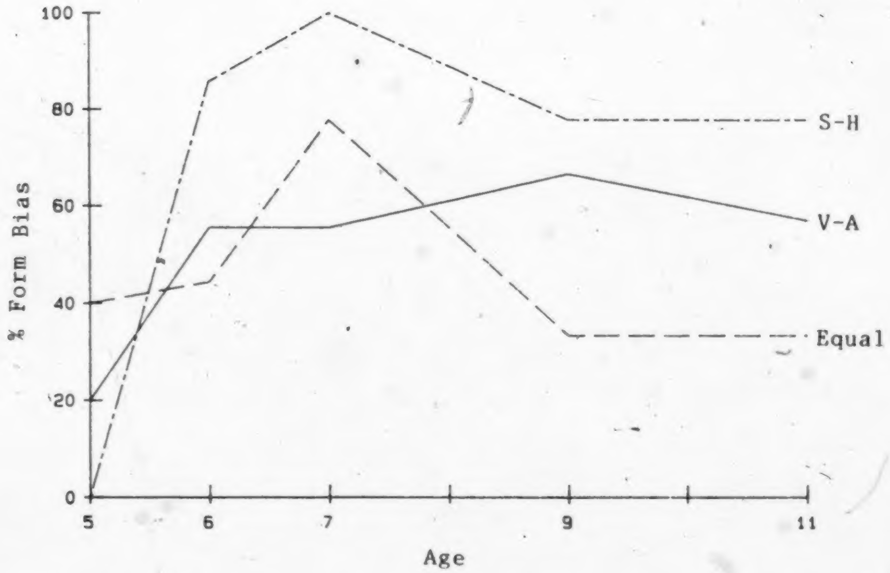


Figure 4-4: Poor Readers' F-F Test means: Cognitive Balance by Age

Table 4-13: Frequency of Form Choices in three age groups with Items ordered by shape complexity

	AGE GROUP					
	5		6 - 9		11	
Total Test		47%		76%		46%
#23 Banana-Orange-Ball	41	87%	128	91%	32	62%
#31 Orange-Moon-Banana	37	79%	119	84%	24	46%
#11 Banana-Banana-Moon	31	66%	98	69%	21	40%
#26 Stars-Moon-Banana	27	57%	108	77%	18	35%
#13 Book-Book-Cake	25	53%	64	45%	16	31%
#36 Cake-Cake-Book	17	36%	86	61%	21	40%
#30 Knife-Cake-Book	19	40%	93	66%	19	37%
#28 Birdhouse-Nest-Basket	16	34%	99	70%	18	35%
#14 Bird-Nest-Basket	16	34%	89	63%	25	48%
# 7 Snake-Snake-Rope	8	17%	77	55%	31	60%
#16 Hose-Hose-Rope	10	21%	85	60%	25	48%
#18 Lizard-Snake-Rope	23	49%	105	75%	28	54%
#33 WateringCan-Hose-Rope	24	51%	104	74%	26	50%
#25 Knife-Fork&Spoon-Sciss	25	53%	113	80%	25	48%
# 5 Bird-Bird-Gloves	14	30%	77	55%	22	42%
#35 Nest-Bird-Gloves	27	57%	102	72%	24	46%
n	47	100%	141	100%	52	100%

[1] Complete data of frequencies for each level of each independent variable on each F-F Test item are presented in Appendix II, Table II-2.

Frequency of Form Responses to each Item at each Age

A ceiling effect seemed to be operating at ages 6 to 9 where more than 70% of the total group gave Form responses on half the items, and in some cases 100% of a subgroup chose Form (see Appendix II, Table II-2). At age 5, the range of frequencies of Form responses was from 17% on #7 Snake-Snake-Rope to 87% on #23 Banana-Orange-Ball (see Table 4-14), from age 6 to 9, frequencies ranged from 45% on #13 Book-Book-Cake to 91% on #23, and by age 11 the range was from 31% on #13 to 62% on #23. The diversity of response frequencies to different items was greatest at age 5. At age 11, the differences between Good and Poor Readers, portrayed in Table 4-14, appear to be a result of more Good Readers choosing Function on certain items -- apparently the ones with simpler shapes, except for the Orange-Ball combination. The transition, then, seems to be from Function responses at age 5 (and probably lower) to Form responses in the middle ages and finally a transition back to Function which starts with Good Readers around age 11 for the simpler shapes. The developmental trend is clear with a definite separation between Reading groups at age 11 giving evidence of external validity in that the F-F Preference Test is differentiating among groups on the basis of these independent variables.

Table 4-14: Percentage of Good and Poor Readers Age 11 choosing Form with Items ordered by shape complexity

			ELEVENS			
			Good		Poor	
#	Function Match	Form Match	n	%	n	%
23	orange-banana	orange-ball	14	52	18	72
31	banana-orange	banana-moon	8	30	16	64
11	banana-banana	banana-moon	9	33	16	64
26	moon-stars	banana-moon	6	22	12	48
13	book-book	book-cake	5	19	11	44
36	cake-cake	cake-book	8	30	13	52
30	cake-knife	cake-book	6	22	13	52
28	nest-birdhouse	nest-basket	4	15	14	56
14	nest-bird	nest-basket	10	37	15	60
7	snake-snake	snake-rope	12	44	19	76
16	hose-hose	hose-rope	11	41	14	56
18	snake-lizard	snake-rope	13	48	15	60
33	hose-watering can	hose-rope	11	41	15	60
25	scissors-knife	scissors-fork&spoon	12	44	13	52
5	bird-bird	bird-gloves	12	44	10	40
35	bird-nest	bird-gloves	12	44	12	48

Effect of Age on F-F Test Items

When Age 6 is excluded from the analyses to provide equal intervals, 14/16 items show the same quadratic effect of Age as the total scores do (see Table 4-15). Only #13 Book-Book-Cake fails to show any significant effect of Age and 6 items show a linear effect also.

Table 4-15: Effect of Age on F-F Test Items: F-Ratios for linear and quadratic terms

Item	Linear Term		Quad. Term		Dev from Quad	
	F-Ratio	Prob	F-Ratio	Prob	F-Ratio	Prob
#23 Banana-Orange-Ball	12.87	.00	5.39	.02	0.00	.96
#31 Orange-Moon-Banana	19.52	.00	10.92	.00	0.53	.47
#11 Banana-Banana-Moon	5.95	.02	3.16	.08	1.57	.21
#26 Stars-Moon-Banana	7.34	.01	15.19	.00	0.00	.99
#13 Book-Book-Cake	0.71	.40	2.53	.11	1.75	.19
#36 Cake-Cake-Book	0.28	.60	8.82	.00	0.48	.49
#30 Knife-Cake-Book	0.45	.50	15.33	.00	0.05	.82
#28 Birdhouse-Nest-Basket	0.13	.72	30.13	.00	0.29	.59
#14 Bird-Nest-Basket	2.45	.12	14.20	.00	0.48	.49
# 7 Snake-Snake-Rope	18.45	.00	9.85	.00	0.87	.35
#16 Hose-Hose-Rope	5.95	.02	19.69	.00	1.02	.31
#18 Lisard-Snake-Rope	0.06	.81	17.78	.00	0.15	.70
#33 WateringCan-Hose-Rope	0.12	.73	12.73	.00	0.05	.82
#25 Knife-Fork&Spoon-Scissors	1.15	.29	9.09	.00	0.33	.23
# 5 Bird-Bird-Gloves	0.76	.39	9.80	.00	1.04	.31
#35 Nest-Bird-Gloves	1.48	.23	9.20	.00	0.24	.62

Correlations: F-F Test Items with Balance and Reading Achievement

Correlational analyses were used at each age to determine which items were the best predictors of Cognitive Processing Balance (using Difference Scores) and Reading Achievement for the 240 subjects (see Table 4-16). Correlations significant at .05 have been taken to be indicators of a possible relationship between an F-F item response and either Cognitive Balance or Reading Achievement.

The only age at which more than 5 out of the possible 16 correlations with either Balance or Reading appeared to be significant was age 11. The strong negative correlations with Reading signified that on items with simpler shapes, with the exception of the circular Orange-Ball item, Poor Readers tended to make more Form choices and Good Readers more Function choices. While there were few significant correlations in any other comparison, the direction of the significant correlations within any set was always consistent; for example, the five significant correlations between F-F response and Cognitive Processing Balance at age 5 were

Table 4-16: Prediction of Balance & Reading from F-F Items at Each Age

Item	Cognitive Balance[1]					Reading Achiev.[2]				
	5	6	7	9	11	5	6	7	9	11
23 Banana-Orange-Ball	-06	11	16	-11	31*	-10	21	-17	19	-21
31 Orange-Moon-Banana	-18	26*	07	14	18	-18	07	-17	05	-34*
11 Banana-Banana-Moon	06	16	-04	04	20	23	11	-03	05	-31*
26 Stars-Moon-Banana	-26*	22	22	00	22	-12	27*	-29*	15	-27*
13 Book-Book-Cake	-42*	-00	-12	-22	16	-14	16	07	05	-26*
36 Cake-Cake-Book	-32*	34*	18	08	10	17	-09	16	15	-23*
30 Knife-Cake-Book	-32*	24*	13	-07	04	16	-05	09	25	-31*
28 Birdhouse-Nest-Basket	-11	-11	17	14	21	40*	31*	-14	15	-43*
14 Bird-Nest-Basket	14	20	02	00	-03	31*	07	-31*	05	-23*
7 Snake-Snake-Rope	01	-13	08	-06	09	-03	12	-06	00	-32*
16 Hose-Hose-Rope	-30*	02	28*	-14	12	07	23*	04	05	-15
18 Lizard-Snake-Rope	-18	02	02	26*	05	24	07	13	-06	-12
33 WateringCan-Hose-Rope	-08	09	-13	-10	21	45*	07	-29*	16	-19
25 Knife-Fork&Spoon-Scissors	07	-06	-13	03	26*	23	09	-14	25	08
5 Bird-Bird-Gloves	-08	-09	00	01	23*	05	31*	-14	-05	04
35 Nest-Bird-Gloves	05	06	17	06	09	14	24*	20	05	-04

[1] Positive correlations imply that Good Readers are more likely to choose Form, Poor Readers Function.

[2] Correlation between Difference Score and Form choice: positive correlation imply that the S-H group is more likely to choose Form.

* Significant at .05

all negative indicating that the children with stronger V-A skills were more likely to choose Form on those Nominal and Relational items. From age 6 to age 11, however, it is the S-H group who are more likely to choose Form on any item where there is a significant correlation. With regard to F-F items and Reading Achievement, items which distinguish between the two groups are more likely to elicit Form responses from Good Readers at ages 5 & 6 but from Poor Readers at ages 7, 9 & 11. In general, factors other than Cognitive Balance and Reading Achievement must be causing the variation in response to F-F Test items, however, as few of the item responses correlate with either of the independent variables examined in this study.

Factor Analyses

Maximum likelihood factor analyses of the 16 item F-F Preference Test were conducted for the total sample (n = 240), for age groups, Balance groups and for Reading groups even though it was understood that the factor analyses of subgroup responses were exploratory only because of small n's. Using a criterion for number of factors of **eigenvalues greater than 1.0**, a 3-factor solution provided the best fit for the responses of the total sample. Communalities and factors for the maximun likelihood solution are presented in Tables 4-18 and 4-19. There appeared to be a strong "Categorical" factor, a "Shape" factor and a "Nominal" factor (see Table 4-19) but the hypothesis of a single bipolar factor was not well supported by the data.

Factor Analyses for each Age Group

Since the independent variable, Age, produced a strong main effect on F-F Test scores, and since the mean scores of 5 & 11 year old were significantly different from the other three groups (see above), factor analyses were conducted on three age groups: five year olds (n = 47), a middle group consisting of 6, 7 & 9 year olds (141), and the eleven year olds (52). Although the 5 & 11 year old groups are too small to provide an adequate factor analysis for a test of 16 items, there was a possibility that the factors might be quite different for each separate age group. A 3-factor solution was clearly the best fit for the responses of the 11 year olds. A combination of size of eigenvalues, a scree test, and examination of the amount of variance was needed before 5 factors could be chosen as the best solution for the middle group and 6 for the 5 year olds. In the initial statistics before rotation, the increase observed in the relative strength of the strongest factor with the increase in age is rather striking -- examining the proportion of common variance accounted for by the first factor in each group (Table 4-17), one sees in the total group 35.4% with a range from 21.7% at age 5 to 42.0% at age 11.

Since the middle age group is the largest and since they made about 70% Form choices, the factors which fit their data will be interpreted first. A mathematical criterion indicates 4 factors but a "scree test" indicates 3 or 5. Examination of the 3-factor solution shows that it only accounts for 39% of the total variance as opposed to 61.5% for the 5-factor solution. The first factor may be called "Categorical" with 5/7 categorical items having salient loadings and only one non-categorical item. The second factor is largely "Nominal" with 4/6 nominal items with one categorical which may be joining two of the coil Form matches. The third factor seems to be a "Mixed" factor with 3/3 Relational items, 2/3 Book-Cake and 2/2 Nest-Basket Form matches. The fourth factor contains the two items most clearly shown in two different ways: closed and open banana and closed and open book (#11 & #13). The fifth factor only had a single item with a salient loading, #23 (Banana-Orange-Ball), which was the only Form match of two circular objects. While the structural validity of the F-F Preference Test on the dimension of factor structure can not be confirmed by this factor analysis of 6 to 9 year olds' responses, three factors are definitely interpretable for the different categorical associations as hypothesized. The test appears to have little structural validity for the 5 year olds, however, since the best solution provides an assortment of 6 uninterpretable factors.

The 11 year old's responses to the F-F Test, however, tended to confirm the structural validity of the test with only two factors accounting for 44.8% of the common variance and a third being much weaker. Twelve of the 16 items spread throughout the test, covering all the nominal items, all but two categorical items plus one relational items have salient loadings on the 11 year olds' first factor called the "F-F" factor. A second, almost equally strong factor involving 6/7 of the categorical items is referred to as a "Categorical" factor and the third, less clear, seems to be a "Mixed" factor with three of the salient loadings involving the Book-Cake Form match. Otherwise the shapes of the Form matches are divided between the first two factors suggesting that the type of shape is not as important as the type of Function match.

In summary, the factor analyses show that the F-F Test is not measuring a simple choice between Form and Function at age 5. From age 6 to 11, however, while influenced by the type of functional association required, the test does seem to be measuring a discrimination between Form and Function with the strength of the association increasing by age 11.

Factor Analyses for each Balance Group

The major hypothesis in this study was that children's Cognitive Processing Balance would strongly influence their choices on the F-F Test with the V-A Group choosing Function more frequently and S-H choosing Form. While that hypothesis was not supported it was still possible that the factor structure would be different for the three Balance groups. The 5 year old data were excluded from these analyses since it was so unreliable and so different from that of the school-age

Table 4-17: Factor analysis of F-F Test Items: Eigenvalues for the total group & three age groups.

	TOTAL GROUP		FIVES	
Factor	Eigval	% Var	Eigval	% Var
1	5.67	35.4	3.47	21.7
2	1.32	8.3	1.74	10.9
3	1.11	6.9	1.62	10.1
4			1.54	9.7
5			1.24	7.8
6			1.22	7.6

	MIDDLE		ELEVENS	
Factor	Eigval	% Var	Eigval	% Var
1	5.19	32.4	6.72	42.0
2	1.44	9.0	1.53	9.6
3	1.19	7.4	1.32	8.3
4	1.07	6.7	.97	6.0
5	.96	6.0	.90	5.6
6	.84	5.3	.82	5.1

Table 4-18: Factor analysis of F-F Test Items by Age group: Communalities for maximum likelihood solution

Item	TOTAL	FIVES	MIDDLE	ELEVENS
#11	.612	.999	.999	.759
#16	.625	.715	.572	.519
# 7	.460	.343	.645	.404
# 5	.206	.200	.200	.206
#26	.499	.923	.588	.623
#13	.384	.458	.355	.607
#36	.374	.297	.554	.423
#25	.433	.575	.359	.759
#31	.402	.549	.360	.503
#28	.485	.494	.490	.544
#33	.362	.393	.317	.382
#18	.366	.551	.317	.419
#23	.192	.301	.999	.179
#14	.322	.999	.270	.471
#35	.318	.271	.327	.409
#30	.357	.464	.423	.999

children. Available for factor analysis, then, were responses from 64 children from the Stronger Verbal-Analytic Group, 61 Stronger Spatial-Holistic and 68 from the Equal Group ages 6 to 11 years. Using scree tests on the Eigenvalues (see Table

Table 4-19: Comparison of factor patterns for various ages with items ordered by functional association, loadings .30 and higher

	FACTORS IN EACH AGE GROUP																
Item	TOTAL GROUP			FIVES						MIDDLE					ELEVENS		
	1	2	3	1	2	3	4	5	6	1	2	3	4	5	1	2	3
Nominal Association																	
#11 Banana-Banana-Moon	-	-	72	65	-	-39	45	-	-34	-	-	-	94	-	80	-	-
#16 Hose-Hose-Rope	-	73	-	38	-	-	-	-	70	-	67	-	-	-	57	37	-
# 7 Snake-Snake-Rope	-	63	-	-	-	-	-	37	36	-	74	-	-	-	44	-	36
# 5 Bird-Bird-Gloves	-	39	-	41	-	-	-	-	-	-	35	-	-	-	41	-	-
#13 Book-Book-Cake	-	36	48	-	48	-	-	-	44	-	37	-	43	-	61	-	43
#36 Cake-Cake-Book	47	-	-	51	-	-	-	-	-	33	-	64	-	-	45	-	44
Categorical Association																	
#25 Knife-Fork&Spoon-Sciss	62	-	-	-	-	74	-	-	-	54	-	-	-	-	-	86	-
#26 Stars-Moon-Banana	66	-	-	-	.95	-	-	-	-	73	-	-	-	-	31	70	-
#31 Orange-Banana-Moon	51	-	37	-	-	-	-	65	-	49	-	-	-	-	50	41	-
#28 Birdhouse-Nest-Basket	55	-	37	-	35	-	45	-	-	46	-	48	-	-	48	37	42
#33 WateringCan-Hose-Rope	51	-	-	42	-	40	-	-	-	41	-	-	-	-	36	49	-
#18 Lisard-Snake-Rope	40	44	-	55	-	33	-	-	30	-	38	33	-	-	-	48	34
#23 Banana-Orange-Ball	39	-	-	-	-	-	-	53	-	-	-	-	-	96	35	-	-
Relational Association																	
#14 Bird-Nest-Basket	-	-	44	-	-	-	97	-	-	-	-	36	-	-	67	-	-
#35 Nest-Bird-Gloves	49	-	-	48	-	-	-	-	-	-	-	42	-	-	-	50	40
#30 Knife-Cake-Book	43	32	-	-	33	55	-	-	-	-	-	48	31	-	-	-	97

Complete results are available in Appendix II, Table II-3.

4-20), the best solutions seemed to be 3 factors for the V-A Group, 5 for the Equal Group and 5 for the S-H Group. Already it was obvious from the number of factors that the Cognitive Balance Groups were somewhat different from each other. The maximum likelihood solutions are presented in Table 4-21. Since Age and Reading Achievement were likely to be acting as **intervening variables**, they were added to the factor analyses to check on their relationship to the factors which best represented the test items alone. If the factors were influenced clearly by cognitive processes and not by the independent variables, then Age and Reading Achievement should come out as separate factors not related to the test items.

The V-A Group data were represented adequately by two stronger factors accounting for 42% of the common variance, one "Categorical" factor with all the categorical items plus three others, one "Nominal/Relational" factor and a much weaker "Mixed" factor. When Age and Reading Achievement were added to the factor analysis, Age loaded on a separate factor joined only by 3/16 items, and Reading Achievement failed to appear at all in the factor space. The three original factors were changed somewhat as follows: fourteen items from all categories and all shapes showed salient loadings on the categorical factor which now looked more like an overall "F-F" factor, the Nominal/Relational factor became clearer, while the last was the same Mixed factor as before. Structural validity was thus confirmed by the results of the factor analyses of the V-A Group especially when Age was included among the variables.

The Equal Group required five factors to represent the data, two of which accounted for 42% of the common variance. The first factor could be called Categorical but the second and third factors were difficult to label. The fourth seemed to be a "Coil" factor and the last an "Orange-Banana" factor. When Age and Reading Achievement were added (see Table 4-22), Age pulled out 3/7

Categorical items with their primary (strongest) loading on the Age factor plus 3 other items with salient loadings (older subjects tended to choose Function), while Reading Achievement was not included at all in the factor space. The other factors were no clearer than before. Structural validity for the Equal Group was not well supported by the results of the factor analyses.

The S-H Group required five factors to represent the data, with three accounting for 40% of the common variance. The first factor was clearly "Categorical" and the second "Nominal". When Age and Reading Achievement were added, however, Age produced a new first factor (18% of the common variance) drawing 2 items with primary loadings and three with secondary, while Reading Achievement loaded on the fourth factor (10% of the common variance) with the two Nest-Basket Form choices (Good Readers tended to choose Function), leaving the item factor accounting for 27% of the common variance. Structural validity was thus not well supported by the results of the factor analyses of the S-H Group's responses.

Comparison of the factor patterns for the three Cognitive Processing Balance Groups showed different sets of factors for each. Age strongly affected the patterns for all three Balance Groups but loaded separately in the V-A Group; Reading Achievement affected only the S-H Group. Structural validity was supported in the V-A Group since the hypothesized unifactorial structure was closely approached, especially when Age was added as a variable to the factor analysis. Structural validity was not supported by the results in either the S-H or Equal Group but the indications of differences in factor patterns among the three Cognitive Balance groups tend to support external validity of the test for differentiation of these groups.

Table 4-20: Factor analyses for Balance groups, ages 6 to 11, for Items only and Items+Age+Reading: Eigenvalues and per cent of common variance after rotation

	Stronger V-A		Equal		Stronger S-H	
Factor	Eigval	% Var	Eigval	% Var	Eigval	% Var
F-F TEST ITEMS ONLY						
1	4.65	29.1	3.07	19.2	3.14	19.6
2	2.74	17.1	3.63	22.7	1.03	6.4
3	.83	5.2	.94	5.9	1.64	10.3
4			.99	6.2	1.61	10.1
5			.60	3.7	1.13	7.1
6						
F-F TEST ITEMS+AGE+READING						
1	4.14	23.0	3.23	18.0	3.18	17.7
2	1.87	10.4	3.74	20.8	1.04	5.8
3	1.90	10.6	1.08	6.0	2.01	11.2
4	1.85	10.3	.91	5.0	1.73	9.6
5			.71	4.0	1.33	7.4
6					.83	4.6

Factor Analyses for each Reading Group

The hypothesis that responses to the F-F Test would be influenced by the level of reading ability was also tested by examining the factor patterns of the Good and Poor Readers (again omitting the 5 year old data). Using a combination of Eigenvalue size and scree tests (see Table 4-23), the best solution appeared to consist of 3 factors for both Good and Poor Readers aged 6 to 11 years with F-F Items only and 5 factors when Age and Balance were included. The factor patterns for each Reading Group, portrayed in Table 4-24, show differences especially when Age and Balance are factored in.

With the Good Readers, there was a strong "Categorical" factor, a Mixed factor and a Nominal factor when only the items were factored. When Age was added, however, 8/16 items had primary loadings and 3 had secondary loadings on

Table 4-21: Comparison of the factor patterns of F-F Test Items for Balance Groups ages 6 to 11 years

Item	FACTORS IN EACH GROUP												
	V-A			EQUAL					S-H				
	1	2	3	1	2	3	4	5	1	2	3	4	5
Nominal													
#11 Banana-Banana-Moon	-	46	88	30	72	-	-	-	-	-	-	-	88
#16 Hose-Hose-Rope	-	64	-	-	30	33	66	-	-	65	-	-	-
# 7 Snake-Snake-Rope	-	54	-	-	-	-	74	-	-	52	-	-	-
# 5 Bird-Bird-Gloves	37	-	-	30	-	-	35	-	-	68	-	-	-
#13 Book-Book-Cake	-	52	59	-	54	-	-	-	-	44	-	-	32
#36 Cake-Cake-Book	49	39	-	-	31	84	-	-	39	-	43	-	-
Categorical													
#25 Knife-Fork&Spoon-Sciss	69	-	-	63	-	-	-	-	60	-	-	-	-
#26 Stars-Moon-Banana	75	-	-	63	-	-	-	34	75	-	-	-	-
#31 Orange-Banana-Moon	37	-	61	32	-	-	-	93	64	-	-	-	-
#28 Birdhouse-Nest-Basket	66	-	41	-	38	55	-	30	40	-	-	51	-
#33 WateringCan-Hose-Rope	37	-	44	72	-	-	-	-	-	-	96	-	-
#18 Lizard-Snake-Rope	32	42	-	40	-	33	37	-	-	-	40	-	-
#23 Banana-Orange-Ball	49	-	-	-	-	-	-	45	55	-	-	-	-42
Relational													
#14 Bird-Nest-Basket	-	-	-	-	63	-	-	-	-	-	-	94	-
#35 Nest-Bird-Gloves	67	35	-	54	-	47	-	-	-	34	-	-	-
#30 Knife-Cake-Book	-	83	-	31	36	43	-	-	39	-	-	-	-

Complete results are available in Appendix II, Table II-4

Table 4-22: Comparison of the factor patterns of Items + Age + Reading for Balance groups, ages 6 to 11

Item	FACTORS IN EACH GROUP														
	V-A				EQUAL					S-H					
	1	2	3	4	1	2	3	4	5	1	2	3	4	5	6
Nominal Association															
#11 Banana-Banana-Moon	43	53	-	71	37	66	-	-	-	-	87	-	-	-	-
#16 Hose-Hose-Rope	-	61	-	-	-	43	61	-	-	-	-	-	34	-	52
# 7 Snake-Snake-Rope	46	52	-	-	-	-	76	-	-	-30	50	-	31	-	36
# 5 Bird-Bird-Gloves	42	-	-	-	31	-	40	-	-	-	-	-	-	-	74
#13 Book-Book-Cake	32	55	-	47	-	57	-	-	-	-	49	-	-	-	-
#36 Cake-Cake-Book	53	37	-	-	-	71	-	48	-	39	-	-	-	45	-
Categorical															
#25 Knife-Fork&Spoon-Scissors	54	-	47	-	62	-	-	37	-	-	-	-	52	-	-
#26 Stars-Moon-Banana	73	-	-	-	59	31	-	30	31	50	-	-	60	-	-
#31 Orange-Moon-Banana	50	-	-	46	37	-	-	-	91	50	33	-	30	-	-
#28 Birdhouse-Nest-Basket	68	30	30	-	-	63	-	34	33	-	-	54	-	-	-
#33 WateringCan-Hose-Rope	50	33	-	-	63	-	-	-	-	-	-	-	-	95	-
#18 Lizard-Snake-Rope	43	34	-	-	-	-	37	39	-	-	-	-	32	37	-
#23 Banana-Orange-Ball	42	-	46	-	-	-	-	-	41	32	-	-	50	-	32
Relational															
#14 Bird-Nest-Basket	47	-	-	-	-	58	-	-	-	-	-	96	-	-	-
#35 Nest-Bird-Gloves	63	36	-	-	-	-	-	74	-	38	-	-	-	-	42
#30 Knife-Cake-Book	-	95	-	-	-	52	-	-	-	49	-	-	-	-	30
Age	-	-	-97	-	-57	-	-	-	-	-78	-	-	-	-	-
Reading	-	-	-	-	-	-	-	-	-	-	-	-44	-	-	-

Complete results are available in Appendix II, Table II-5.

Table 4-23: Factor analyses for Reading Groups, ages 6 to 11, for Items Only & Items+Age+Balance: Eigenvalues and per cent of common variance

	F-F TEST ITEMS ONLY				F-F TEST ITEMS+AGE+BALANCE			
	Good		Poor		Good		Poor	
Factor	Eigval	% Var	Eigval	% Var	Eigval	% Var	Eigval	% Var
1	5.46	34.1	3.24	20.2	2.39	13.3	4.46	24.8
2	.96	6.0	3.27	20.4	4.49	24.9	.96	5.3
3	.80	5.0	.76	4.8	.85	4.7	1.38	7.7
4					.83	4.6	1.96	10.9
5					.51	2.8	.66	3.7

an "Age" factor, suggesting that Age is a strong influence on F-F Preference Test responses for Good Readers, although Factor II, "Form" (Coil/Rectangle/Gloves), accounts for almost twice as much of the common variance (25% vs 13%). Besides two weaker item factors there was also a weak factor consisting of Balance and two items. Structural validity was, therefore, not supported by the results of the Good Readers.

With the Poor Readers, on the other hand, two equally strong factors accounted for 40% of the common variance: a "Categorical/Relational" and a "Nominal" factor plus a weak "Banana-Moon" factor. When Age and Balance were added to the factor analysis, a strong "F-F" factor appeared along with a "Categorical" factor and two "Mixed" factors. Age appeared alone drawing only a single item weakly to the "Age" factor, showing that Age did not relate to the factors created from item responses of Poor Readers and neither did Balance which did not appear at all. Structural validity is, thus, supported by the results of factor analyses of the Poor Readers both through the clear item factors and the fact that neither Age nor Balance were related to those factors.

The factor patterns of Good and Poor Readers were somewhat different from

Table 4-24: Comparison of the factor patterns for Balance groups: F-F Test Items only and Items + Age + Balance, for ages 6 to 11

Association	ITEMS ONLY						ITEMS + AGE + BAL									
Item	Good			Poor			Good					Poor				
	1	2	3	1	2	3	1	2	3	4	5	1	2	3	4	5
Nominal Association																
#11 Banana-Banana-Moon	-	78	-	-	34	92	35	-	58	-	37	-	88	41	-	-
#16 Hose-Hose-Rope	-	-	67	-	75	-	-	65	-	-	-	70	-	-	-	-
# 7 Snake-Snake-Rope	-	-	60	-	67	-	-	50	33	-	-	66	-	-	-	-
# 5 Bird-Bird-Gloves	-	-	33	31	35	-	-	39	-	-	-	44	-	-	-	-
#13 Book-Book-Cake	-	61	45	-	41	37	-	-	76	-	-	34	48	-	-	-
#36 Cake-Cake-Book	45	38	-	58	-	-	43	43	-	-	-	-	-	-	94	-
Categorical Association																
#25 Knife-Fork&Spoon-Sciss	69	-	-	61	-	-	69	-	-	-	-	33	-	53	-	31
#26 Stars-Moon-Banana	83	-	-	62	-	-	82	-	-	-	-	-	-	69	-	-
#31 Orange-Banana-Moon	59	36	-	49	-	35	64	-	-	-	-	-	-	55	-	-
#28 Birdhouse-Nest-Basket	60	65	-	62	39	-	70	-	30	-	34	46	-	39	40	-
#33 WateringCan-Hose-Rope	38	-	37	64	-	33	33	40	-	-	-	-	-	56	34	-
#18 Lisard-Snake-Rope	34	-	33	44	42	-	32	42	-	-	-	49	-	39	-	-
#23 Banana-Orange-Ball	52	-	-	42	-	-	49	-	-	-	-	33	-	-	-	-
Relational Association																
#14 Bird-Nest-Basket	-	52	-	43	30	-	-	-	-	92	-	33	-	-	-	-
#35 Nest-Bird-Gloves	49	-	-	54	35	-	46	43	-	-	-	45	-	-	33	-
#30 Knife-Cake-Book	40	33	-	36	47	-	40	39	-	-	-	44	44	-	37	-
Age							-62	-	-	-	-	-	-	-	-	-95
Balance							-	-	-	-	35	-	-	-	-	-

Complete results are available in Appendix II, Table -I 6.

each other when only test items were factored but when Age and Balance were added in, then important differences appeared. Age loaded on a strong factor for Good Readers involving over half the items, thus, showing Age to have an important effect on Good Readers' responses to the F-F Preference Test. With the Poor Readers, however, structural validity was supported by the results since two clear item factors appeared and Age loaded on a separate factor.

SUMMARY OF CONSTRUCT VALIDITY OF THE F-F TEST

The F-F Test of Preference for Cognitive Processing Strategies has been developed according to Loevinger's (1957) model for test development. Results for the substantive component of construct validation have been presented in chapter 3, analyses of the structural and external components in this chapter. The final version of the test made up of 16 items seemed to present a clear choice to all subjects aged 5 to 11 years. The test is internally consistent and showed test-retest reliability, especially at the older ages tested. The factor structure was consistent with the hypothesis that the test items and distractor items would occupy different factor space.

The independent variables used to test the external component of validity were fully crossed with approximately equal numbers in each cell (see Research Design above). Age levels were selected to include pre-reading and early reading at one-year intervals plus two later ages resulting in age levels of 5, 6, 7, 9 and 11 years. Subjects were divided into three Cognitive Processing Balance Groups, Stronger Verbal-Analytic, Equal and Stronger Spatial-Holistic, through the use of four Wechsler subtests. Two levels of Reading Achievement included Good Readers (above the 50th percentile) and Poor Readers (below the 30th percentile). While the Age and Cognitive Balance groups proved to be equal in IQ, the Poor Readers produced lower extrapolated IQ scores which, however, did not significantly affect responses to the F-F Test.

Analyses of Variance of F-F Test scores showed a significant effect of Age with a significant interaction between Age and Reading Achievement. The hypothesized effect of Cognitive Processing Balance on F-F Test scores was not confirmed by the data. The nature of the Age effect was curvilinear with a significant quadratic term such that 6, 7 & 9 year olds were indistinguishable from each other with mean Form choices averaging 11 out of 16. Five and 11 year olds, on the other hand, made about 8 Form choices. All but two of the 16 items show the quadratic effect of Age on the F-F Test. Examination of the interaction between Age and Reading Achievement showed that at age 11 Poor Readers made significantly more Form choices than did Good Readers, 9 versus 6 out of 16.

The pattern of correlations between the F-F Test Items and three external criteria, Cognitive Processing Balance, Age and Reading Achievement, was also examined. It was only at age 11 that more than half of the items were significantly correlated with Reading Achievement. Structural validity was also tested through examination of the hypothesis that most of the test items would load strongly on one factor with other factors being much weaker. While the factor structure of the test items changed with age, the solution which best fit the 11 year old data consisted of one strong factor on which all but four of the items had significant loadings. The 5 year olds did not seem to regard the test as a simple choice between Form and Function.

While keeping in mind the small number in each group, it was encouraging to note that factor patterns for the different Cognitive Balance Groups (ages 6 - 11) seemed to differ, especially when Age and Reading Achievement were entered into the factor analyses. Although structural validity was not supported by the results for the S-H and Equal Groups, the Stronger Verbal-Analytic Group data produced a single strong factor on which all but two of the 16 items showed salient loadings; as well, the item factors remained clear with no relationship to Age or Reading Achievement. Structural validity was also supported in the group of Poor Readers with the factors being interpretable and not related to Age or Balance.

The F-F Test of Preference for Cognitive Processing Strategies definitely has no validity as an instrument for predicting the three Cognitve Balance Groups in children from the ages of 5 to 11 years. The test is a valid indicator, however of differences in preference for Form or Function matches at ages 5, 6 to 9, and 11 years. Furthermore, by age 11, Poor Readers lag significantly behind Good Readers in making a transition from Form to Function choices. There is an indication that the F-F Preference Test may be valid in showing differences among the Balance groups within the Reading groups past age 11 but that has not yet been demonstrated.

LIMITATIONS OF THE STUDY

The study was limited in three major areas. The first involved the number of subjects. One hour of testing time was required to administer the screening tests plus an additional half hour to administer the remaining three tests for those subjects selected for the study sample. Consequently, it was not practical to screen a large random sample in order to test fully the theory of Cognitive Processing Balance, especially with regard to the prevalence of stronger Verbal-Analytic and stronger Spatial-Holistic skills among boys and girls and among good and poor readers. In order to do this, a random sample of at least 50 boys and girls in each of the reading groups at each age would have been necessary. It was not practical to attempt to test 1,000 subjects for this study.

In selecting subjects for the study it was also not practical to administer common standardized reading tests to all of the participants. It was necessary, therefore, to rely upon verification of the subjects' current academic performance by teachers' report as well as by relying on the validity of the standardized tests given in each school. Reading achievement was only added to the study after arrangements had been made to test in both the Edmonton Public School District and in Sherwood Park School District as well. While Edmonton provided scores for Decoding and Comprehension on the Edmonton Public School Board Reading Test, Sherwood Park used the Metropolitan Test for Grades 1 to 3 and the Canadian Test of Basic Schools for Grades 4 to 6; both tests produce global reading scores. Membership in the Good and Poor Reading groups was thus determined by different tests for several subsets of the subjects in the sample. Furthermore, children who had failed a grade were assumed to be Poor Readers but no reading scores standardized for their age cohort were available.

The third area in which the study was limited involved the small number of subjects found to satisfy the sample selection criteria for each of the 20 cells. The results obtained may, nevertheless, be useful in indicating trends that exist with regard to the target population's performance on the F-F Preference Test and thus to suggest possibilities for further research in order to explore the use of the test further with much larger samples.

The fourth and most serious limitation is that Gender had to be eliminated from the study because of the difficulty of finding equal numbers of boys and girls in each group. Since there is considerable evidence that boys and girls may be different both in the balance between Verbal-Analytic and Spatial-Holistic processing and in their use of these cognitive modes, it is important to compare boys and girls both for incidence in the Cognitive Processing Balance groups and for their performance on the F-F Preference Test.

The final limitation that must be noted concerns the order of items on the F-F Preference Test: although the items were randomly assigned to order of presentation, most of the nominal items appeared at the beginning of the test with the categorical and relational items occurring in the second half. An improvement would have been to plan the presentation order for items and then give a reversed order to half the sample. This could be done in future studies using the F-F Preference Test.

5. DISCUSSION AND CONCLUSIONS

The present study was undertaken to investigate the relationship between children's abilities in using the modes of cognitive processing characteristic of each hemisphere and their preference for using the mode for which they show more ability. This investigation extends the work of Bogen (1969), Ornstein and Galin (1975), Reynolds (1981) and Zenhausern (1978) who have hypothesized that individuals whose right or left cognitive modes are more efficient will show "hemisphericity", i.e. a bias toward the use of the information-processing style of that hemisphere. Zaidel spoke of the style of the left hemisphere being "combinational feature analysis" while the right hemisphere employs "convention-bound template matching" for pattern recognition. Levy (1974) concluded that a match for the right hemisphere was interpreted in terms of "visual similarity" and for the left hemisphere in terms of "conceptual categorization but her research with these kinds of matching tasks had only involved a small number of commissurotomized patients using chimeras presented half to each visual half-field. In order to measure preference for either style of cognitive processing with normal children and adults a much simpler test was desired which would involve a minimum of equipment and training. To this end, the F-F Preference Test was developed.

The guiding principle in the development of the F-F Preference Test was that the validation process should be integrated with the entire program of test construction, rather than being tacked on when the test is in final form. This point of view has been ably expressed in Loevinger's (1957) monograph. Loevinger suggested that the validation procedure be divided into **substantive, structural** and **external** components, each of which is a necessary stage in test development and there would be an orderly progression from one stage to the next.

The **substantive** component of validity refers to the degree to which the items comprising a test reflect on theoretical grounds an appropriate universe of content. The F-F Preference Test was developed to measure the strength of an individual's preference for either a left or right hemisphere-type of cognitive mode on a matching test given ambiguous instructions regarding the type of match intended. The first step was the careful formulation of a theoretically-based definition of the type of discrimination to be made in showing a preference for one cognitive mode over another. This process was abetted by a careful perusal of reference works and empirical studies in human neuropsychology and hemispheric asymmetry. The F-F Preference Test offers subjects a choice between line drawings of a Form match (visual similarity) and a Function match (conceptual categorization) when the instructions are ambiguous: "Point to the picture that seems to you to go better with the upper one. They both belong to it but in different ways. Pick the one you prefer." The original pairs of Function and Form line drawings were based on the chimeras used by Levy (1974) with commissurotomized patients: knife-cake-hat, nest-bird-gloves, bird-nest-basket, knife-fork&spoon-scissors. A number of other items were then generated using the same basic format: a picture which can be paired with one through a functional association or with another which has a similar form.

The **structural** component requires that the investigator make explicit, prior to data-gathering, a structural model to which item responses are expected to conform. In this study, in which a homogeneity model was predicted, the estimates of internal consistency reliability confirm the model although the factor analyses cast some doubt at ages below 6 years. The homogeneity hypothesis is confirmed by the Stronger Verbal-Analytic group and the Poor Readers but not well by the other two Balance groups and the Good Readers.

The **external** component of validity refers to the degree to which test variables correspond to non-test manifestations of the same trait or the degree to which the pattern of correlations relate to the nomological network of theoretical predictions. The F-F Preference Test did not fare so well on this score but interesting unpredicted patterns appeared in this exploratory study.

The major hypothesized relationship between stronger Verbal-Analytic skills and Function choices, stronger Spatial-Holistic skills and Form responses was not confirmed. There was no main effect of Cognitive Processing Balance on F-F Preference Test scores and no significant interaction with Age or Reading Achievement. Although it seems reasonable to assume that an individual would tend to rely primarily on the stronger mode in problem-solving, that relationship has not yet been clearly demonstrated. In fact, a number of recent studies have failed to show significant correlations between measures of hemisphericity and laterality measures (Beck, 1980; Clemens, 1981) or measures of hemisphericity and other independent variables (Eisert, 1979; Ferraró, 1982; Schuler, 1982; Shifren, 1982). Other researchers have also failed to find such relationships in their own study (Arndt and Berger, 1978) and they disputed the evidence of such a relationship claimed by Bogen and his colleagues (1972) and by Galin and Ornstein (1974) in their studies.

There was certainly no difficulty in finding school children who had a distinct imbalance in cognitive processing skills in favour of stronger Verbal-Analytic or stronger Spatial-Holistic skills, even though it was more common to find children with equal ability for both modes. If an imbalance in skill level was what Reynolds (1981) meant by "hemisphericity" then his finding is confirmed by this study.

The second major finding in the analyses confirmed the hypothesis that Age would significantly influence responses to the F-F Preference Test. The relationship was quadratic with 5 year olds making fewer than 50% Form choices, 6 to 9 year olds making approximately 70% Form choices and the 11 year olds making fewer than 50%. The question then presented itself as to whether the Form choices were being made for the same reasons at each age and whether the task of choosing between the pictures is even a similar cognitive task for children throughout the span of 5 to 11 years. In other words, for 6 to 11 year olds to make a Form match may be template matching for pattern recognition, but for 5 year olds it may be a complex discrimination which requires analytical processing. In any case, there was a strong developmental shift between age 5 at the end of kindergarten and age 6 at the end of Grade 1. A second, possibly more important shift occurred between the ages of 9 and 11 years.

Consider first the task for the 5 year olds: a choice of Form would require the ability to abstract spatial attributes and to categorize according to the shape of the object disregarding the verbal label. In a discussion of the ways in which parents label objects for young children, Callanan (1985) states: "The structure of our knowledge about objects in the world is based on our perception of similarity among objects, and on our notions of important relations among classes of objects." Thus, a parent showing a book to a very young child may say: "Here are a lot of animals -- there's a snake and that's a lizard: can you find the bird sitting on the nest? This is a page of things you can eat: show me the orange and the banana." In a recent review of picture books for young children. Wright (1986) surveys the area of "concept books" which introduce the essential elements of objects or abstract ideas. She presents books that expand children's awareness of alphabets, numbers, rhymes, opposites and seasons and even visual discrimination but nowhere is there a mention of a visual analog of the kind of word-play involved in homonyms, pictures with the same shape but different meanings. In our culture, a young child's attention is drawn to functional associations and, therefore, in matching easily identified pictures the use of verbal labelling and functional associations would seem to be a simpler process than the more elaborate one of determining the shape while ignoring the conceptual content of the picture. Until kindergarten, few children are asked to ignore the meaning of pictures and to find objects with the same shape: "How many round objects can you find on this page? How many rectangles can you find?"

In most kindergartens, learning about geometric shapes and their names and making visual matches on reading readiness worksheets are greatly emphasized. Commonly, the kindergarten teacher has children sort, trace, colour and name geometric shapes - usually two dimensional but sometimes three dimensional shapes. Children are also given fairly complex verbal cues for remembering the names of geometric shapes (K. Koyata & Y. Kerber. Personal communications, October, 1980):

1. A **Circle** is round.

2. A **Square** has 4 corners and 4 straight sides.

3. A **Rectangle** has 4 corners also but it has 2 long sides and 2 short sides.

4. A **Triangle** has 3 points and 3 straight sides (Chambers, 1975).

5. A **Sphere** can be rolled in any direction like a ball but a **Cylinder** can only roll one way, not end over end (Platts, 1972).

With reference to the learning of the alphabet, Samuels (1973) states that attaching verbal labels to printed stimuli helps children to remember them but, as well as verbal labels, these are complex verbal clues which require a good auditory memory for them to become part of a 5 year old's repertoire of criteria for identifying shapes. Perhaps the children who are able to commit these clues to memory and use them in different situations have more efficient methods of rehearsal. One kindergarten teacher commented that some children would follow the physical actions demonstrated for distinguishing between 3 dimensional shapes but didn't use the labels or repeat the instructions aloud; e.g. they would roll spheres and cylinders but didn't name them and didn't say aloud "spheres can roll in any direction but cylinders can only roll one way." Other children who repeated the verbal clues aloud and who named the shapes when at the sorting task were reported to be more likely to find and name shapes elsewhere in the kindergarten room. Children who were more skillful and more verbal seemed to be practising the shape-naming task on their own in the rest of their lives. In any case, 50% of the Stronger V-A and Equal 5 year olds showed a preference for Form while fewer than 10% of the Stronger S-H did.

The fact that 5 year olds were more likely to choose Function on the F-F Preference Test while older children chose Form is consistent with Piaget's (1969) statement that as children grow older they develop new cognitive processes so that by the time they are 6 or 7 years old their attention is no longer caught by the dominant features, and they can act mentally on a picture, exploring it visually, analyzing it and integrating its features. This final impression, he said, would be a reconstruction of the pictorial elements. Elkind's (1977) study in which 4 to 11 year olds looked at large pictures made up of smaller wholes (such as a man made from pieces of fruit) confirm's Piaget's statement. When they looked at the pictures, the young children generally saw only the fruit but some saw only the man. The young children lacked the cognitive development that would allow them to recognize that a picture could have more than one meaning. A 4 year old, therefore, tended to see an apple, pear, grapes and bananas, but a 9 year old would describe the picture as a "man made out of fruit." Some 5 or 6 year olds could see both, but they were restricted by being able to see only one way at a time. It is quite possible that the 5 year olds in this study would have been able to follow instructions to "choose the picture that looks like this one" just as the 4 & 5 year old children in the pilot-test group were able to. On the other hand, when given ambiguous instructions they were more likely to match by Function.

By the age of 6 years, after a year's experience in Grade 1 learning to read, a task in which the shape of the configuration gives a symbol or word its meaning, the children have had much training in matching objects (letters and words) by Form rather than Function. This training seemed to carry over as 70% of 6 year olds tended to see the F-F Preference Test as a visual matching task. This trend continued upward as 70% of 7 and 9 year olds also understood the instructions to imply a visual matching task.

At age 11, a dramatic change appeared as only 42% showed a Form preference and the other 58% showed a preference for Function. Many researchers have found cognitive changes occurring around the age of 11 years (Bakker, Teunissen & Bosch, 1978; Carey, 1981; Carmon, Nachshon & Starinsky, 1976). According to Piaget (Inhelder & Piaget, 1958), children enter the stage of formal operations around age 11 even though the abstract, scientific thought is not firmly established until about age 15. Other studies suggest that formal thought is neither as inevitable nor as universal a step in development as is the concrete thought of childhood (Neimark, 1975). Research in third world countries and with different socio-economic groups in North America indicates that abstract categorization and reasoning may not be an inevitable outcome of growing up but the direct result of formal education (Cole, 1978; Dulit, 1972; Kohlberg & Gilligan, 1971; Peel, 1971).

The appearance of a developmental shift from Form to Function preference between ages 9 and 11 may be caused by a gradual change in emphasis in our schools from the visual matching which is crucial to the early reading task to an emphasis on the Verbal-Analytic skills of functional and hierarchical classification. Certainly, in the grade 5 curriculum in Alberta, the study of three levels of government in Canada requires a great amount of V-A skill. Further research with larger groups of children in the age range of 10 to 16 years might illuminate developmental changes in preference for cognitive strategies.

The third major hypothesis in this study concerned the effect of Reading Achievement on F-F Preference Test scores. While the main effect of Reading Achievement was not significant, the interaction was, resulting in a significant difference between Good and Poor Readers at age 11. Good Readers chose Form about one-third of the time while Poor Readers chose Form more than half the time. Another way of looking at the responses is to note that 30% of the 11 year old Good Readers showed a Form bias but 56% of the Poor Readers did. Examination of the graph of the Age by Reading Achievement interaction indicates that the Poor Readers may lag behind the Good Readers in making the transition from Function to Form at ages 5 and 6 and behind again in the transition from Form to Function at age 11.

Existence of such a maturational lag would be consistent with the theories of Satz and his colleagues (Satz, Friel & Rudegair, 1974) who explained developmental dyslexia as "a delay in those crucial early sensori-motor and later conceptual linguistic skills which are intrinsic to the the acquisition of reading and which are triggered by a lag in the maturation of the cerebral cortex." A six year follow-up (Satz et al., 1978) showed increases in numbers of both severe and mildly retarded reading groups from kindergarten to the end of Grade 5. From these results Gaddes (1980) concluded: "The increase in the incidence of reading retardation probably results from the inability of the dysfunctioning brain to handle material that makes increasing demands in complexity and flexibility."

Although the three-way interaction between Age, Cognitive Balance and Reading was not statistically significant, in exploratory research it is important to look at trends as well as significant differences. The group of Poor Readers with the highest Form scores were those with stronger Spatial-Holistic skills, like Nancy who was described at the beginning of the paper. They would fall into the group of disabled readers which Boder (1976) called "dysphonetic" and Pirozzolo (1979) called "visual-spatial dyslexics." They were all found in regular Grade 6 classes having passed each grade with the other children in spite of poor reading achievement; their difficulties could be expected to increase as the reading demands increase in all subjects at higher levels. Children with reading problems, strong spatial-holistic skills but weak verbal-analytic skills would benefit from a highly visual and concrete approach using maps, films, etc. (Gaddes, 1980, p142 & 147). In teaching complex analytical subjects like government, it would be advisable to keep the three levels separate and not to expect the children to be able to take a test covering all three at once. Gaddes (1980) recommends that "if an idea is difficult for a child to grasp by verbal explanation alone, he or she should be provided, as much as possible, with accompanying graphic material related to it, because the level of difficulty is a determiner of the child's cognitive strategy and hemispheric emphasis." In this study, S-H Poor Readers were seen to be still choosing Form, like the younger children, rather than Function, like the 11 year old Good Readers.

Another area of concern might be the learning of the rules of spelling, punctuation and grammar. The rote chanting of rules used in old-fashioned schools might help these children to fix such rules in their long term memories, since poor auditory memory is one of the distinguishing characteristics of children of a dysphonetic type. These children probably also need to learn to pay more attention to the component parts of words and sentences, rather than treating words and phrases as global entities (Zenhausern, 1981).

A difference between Stronger S-H and Stronger V-A Poor Readers at age 11 was that the latter proved impossible to find in regular Grade 6 classes while the former were easily identified by the teachers (Appendix III, Table III-1). The Stronger V-A Poor Readers came from children who had been held back to repeat a grade in school. It is possible that the Stronger V-A children have more trouble learning to read in Grade 1, a situation consistent with the theories and findings of Bakker (1979), Belmont (1974). Rourke (1982) has postulated that a right hemisphere orietation is needed in the early stages when reading is a novel and predominantly visual-spatial task. Rourke also argued that the most efficient system in advanced reading would be to have the left hemisphere systems "automatized" and this may be something which has proved difficult or impossible for the Stronger S-H 11 year olds whose left hemisphere (verbal-anlytic) skills are much weaker.

One group of 5 year olds who seemed somewhat different from the others were those with Stronger Verbal-Analytic skills and Good Pre-reading ability who tended to make more Form choices than did other 5 year olds. Since the task they were given was to choose one of two pictures "to go with" a third picture, these children seemed to decide that Form was a more important way of "putting pictures together" than Function. Thus, the more academically ready 5 year olds with Stronger V-A skills may have been better able to generalize their kindergarten lessons about shape so that they looked for visual similarities at times when they might otherwise have been attending to conceptual content as a younger child does. In a pilot-test group of 5 year olds who had 6 month's less exposure to kindergarten but were the same age, the 6 reading-ready children with a V-A bias made an average of 7 form choices rather than 10.5 like the 5 year old study sample. Prior to their kindergarten experience, therefore, these children with a Verbal-Analytic Balance and Good Pre-reading skills would likely have been making predominantly Function choices as the other groups were still doing at the end of kindergarten.

In summary, at age 5 matching by shape may involve an "analytic logical task for which words are an excellent tool" (Galin, 1976, definition of his term "verbal-analytic"). For kindergarten children, matching drawings of familiar objects (rather than geometrical designs) by shape is an unfamiliar task which requires abstracting a new set of attributes and constructing new categories based only on Form -- according to Nebes (1977) this is a left hemisphere task which, in this case, is probably conducted using **serial processing.** The naming of simple objects may actually be the task which is accomplished using parallel or holistic processing.

While the F-F Preference Test has not proved to be a predictor of hemisphericity or to show correlations with measures of Cognitive Processing Balance, it does show important differences in preference for Form or Function over a range of ages from 5 to 11. Five year olds choose Form for half the items and Function for the other half with 75% of the Stronger Verbal-Analytic group who are ready to learn to read showing a preference for Form but only 10% of the Stronger Spatial-Holistic Group. A developmental shift then appears and 6, 7 and 9 year olds choose about 70 % Form with no apparent differences between Reading Achievement or Cognitive Balance Groups. Finally, another shift appears between ages 9 and 11, with 35% of Good Readers and 60% of Poor Readers showing a Form preference. While there is no difference among the Balance groups within the Good Readers at age 11, among the Poor Readers some tantalizing trends appear: Poor Readers in the Equal Group are roughly equivalent in the preferences to Good Readers, the Stronger V-A Poor Readers are in the middle with 55% Form preference but the Stronger S-H Poor Readers look like 9 year olds with about 85% preferring Form on the test. More testing at age 11 and older is needed to validate these trends.

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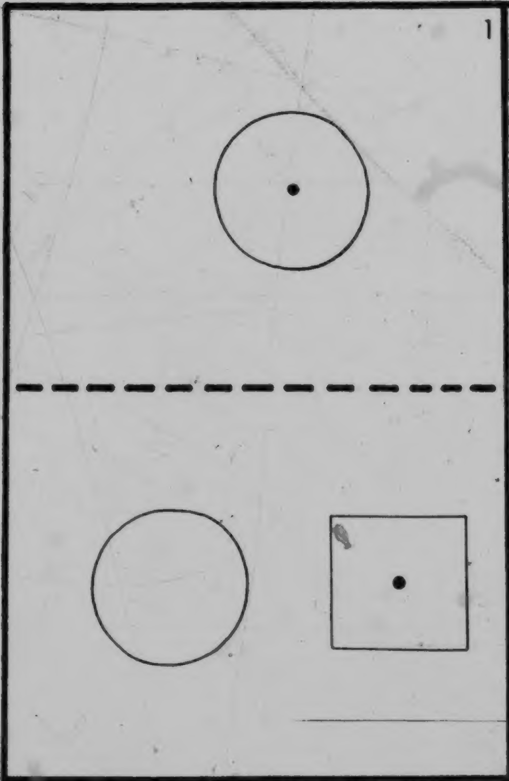
I. THE F-F PREFERENCE TEST

TEST ITEMS AND DISTRACTORS: 40 CHOICES

1



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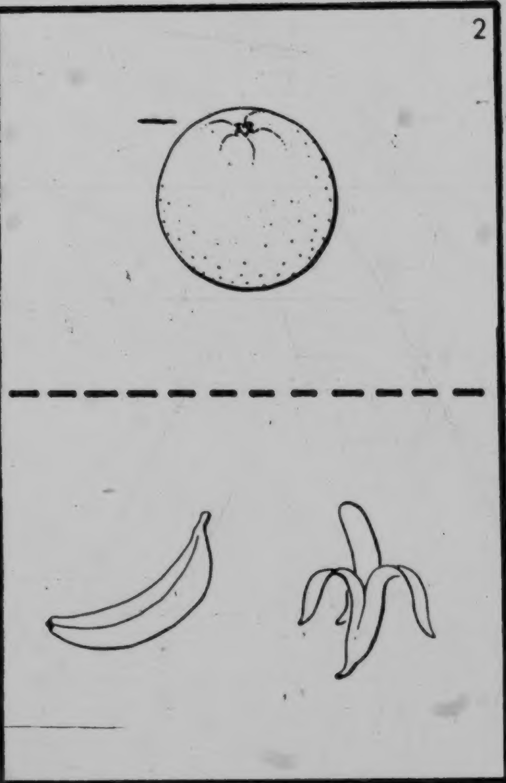

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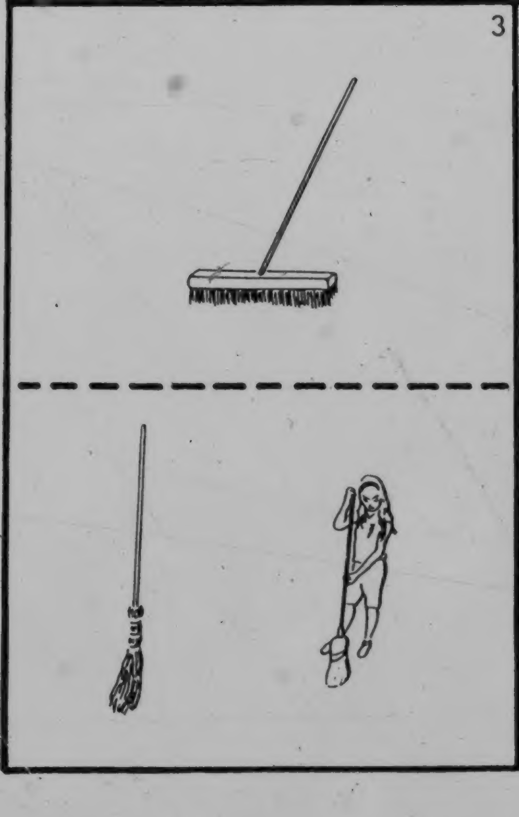

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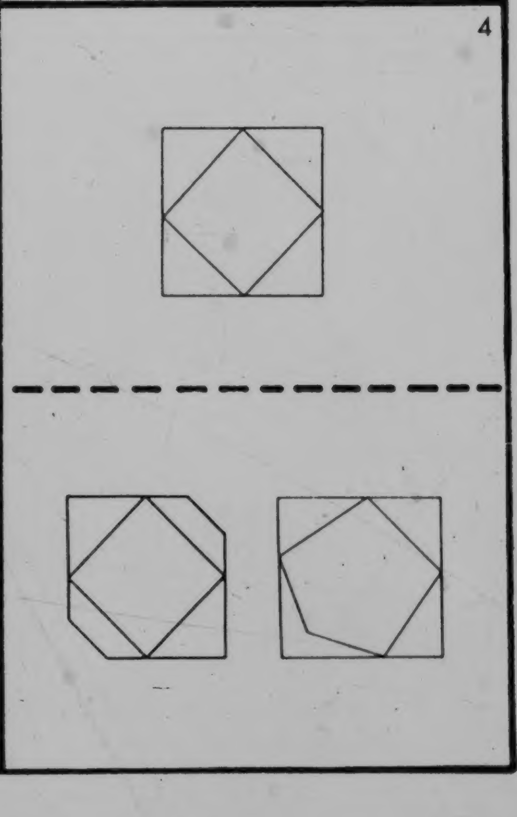

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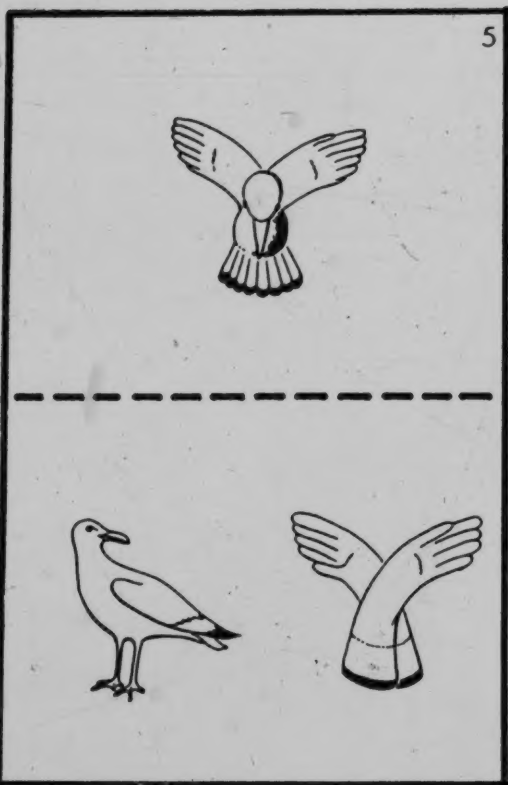

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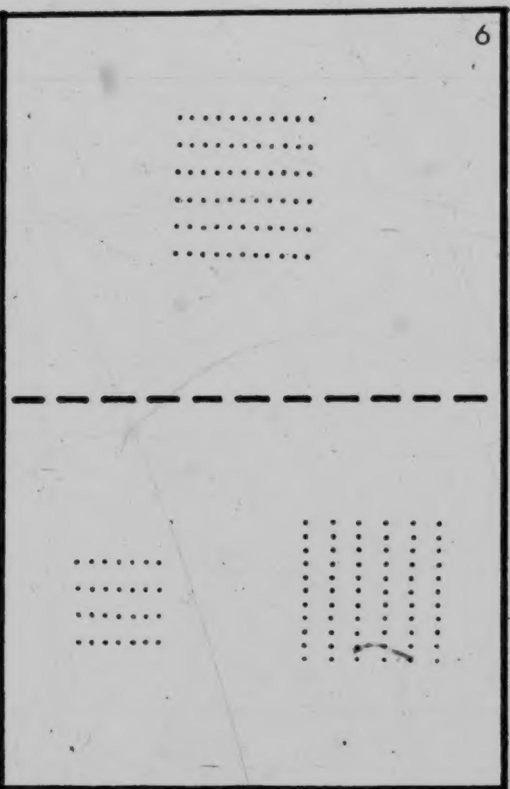

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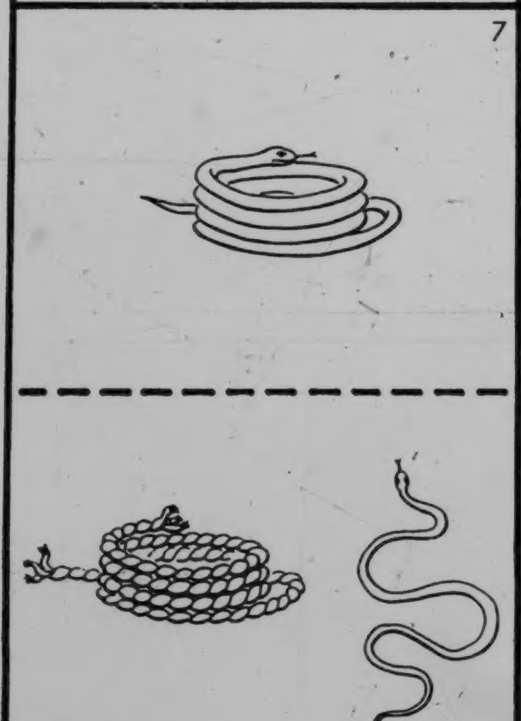

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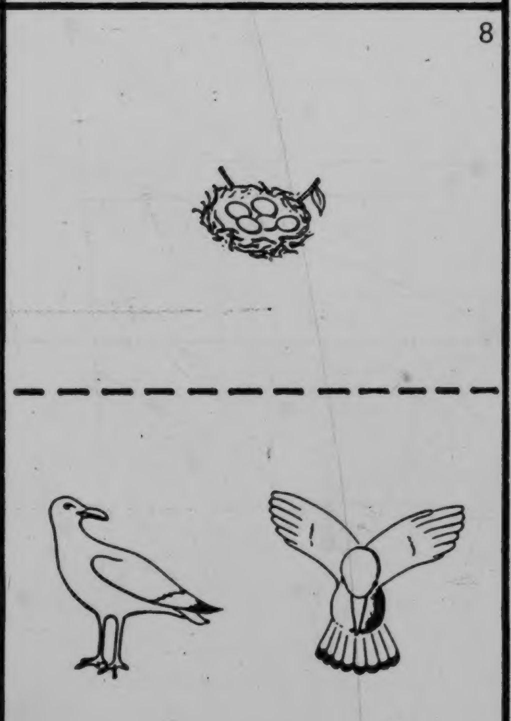

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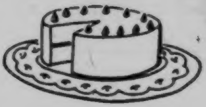

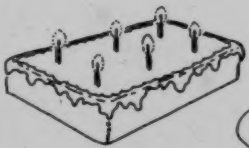

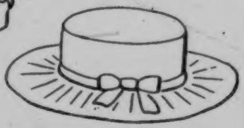

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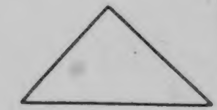

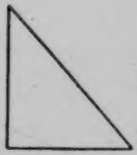

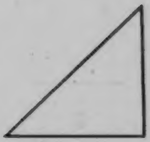

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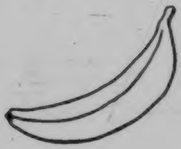

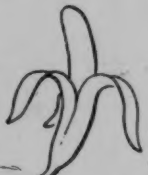

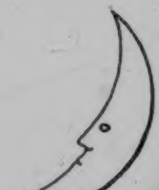

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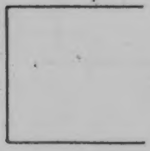

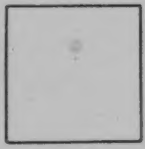

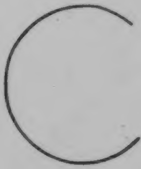

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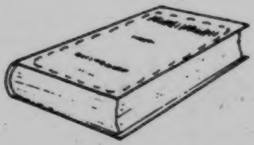

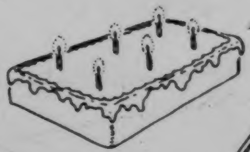

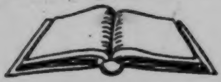

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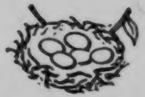

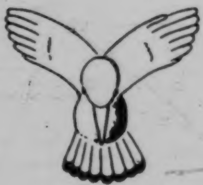

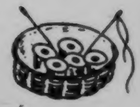

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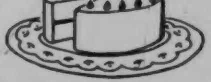

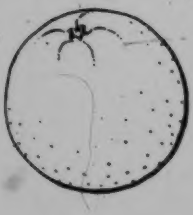

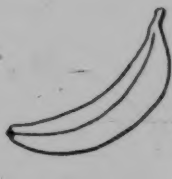

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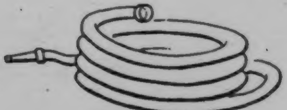

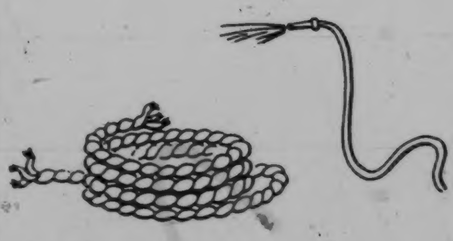

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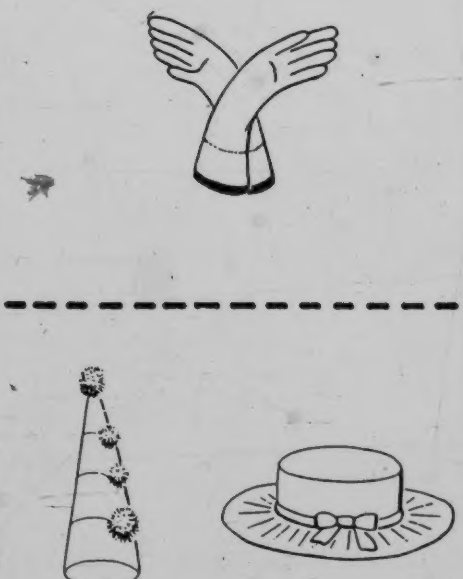

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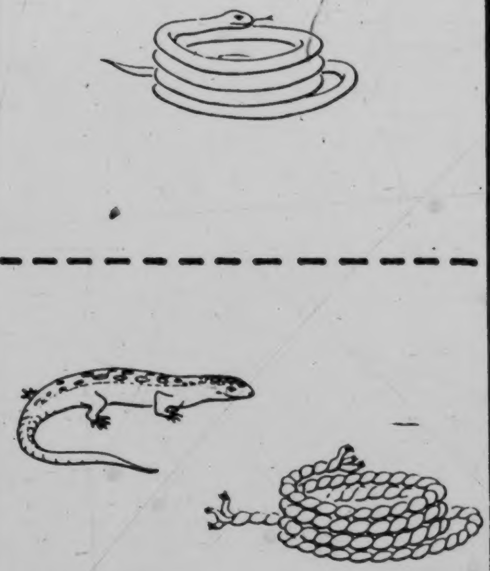

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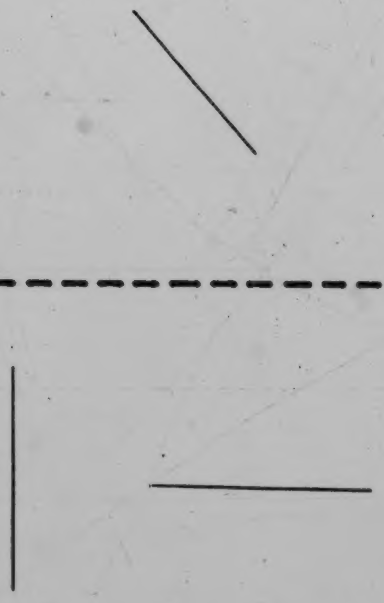

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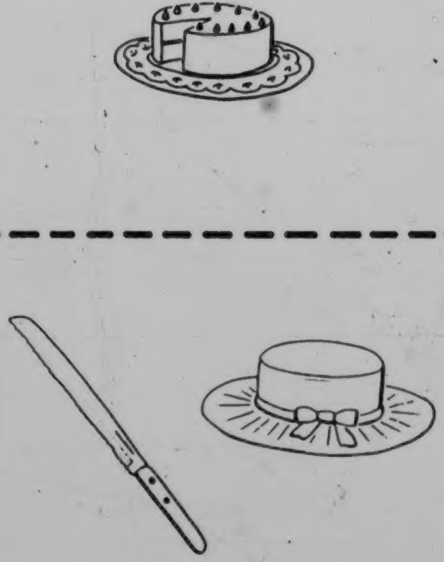

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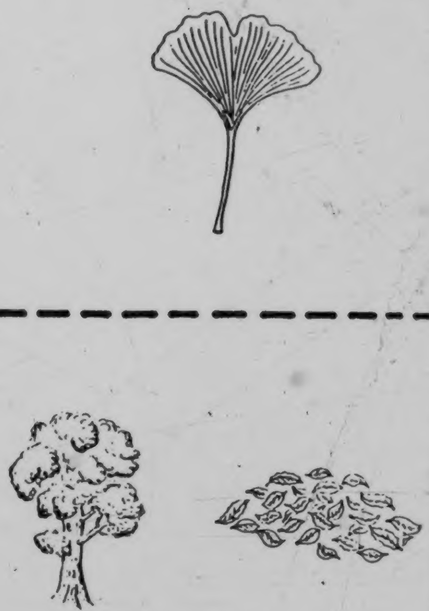

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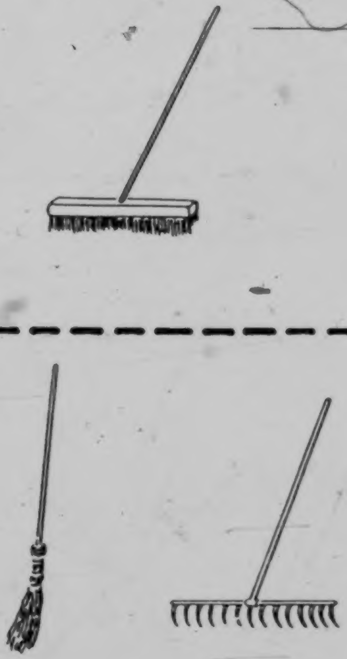

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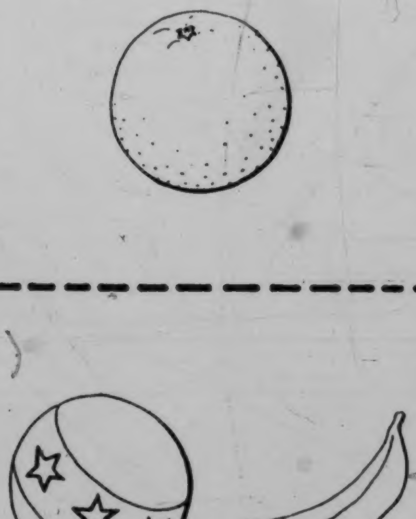

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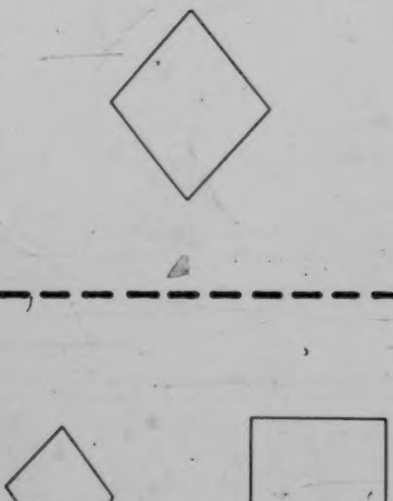

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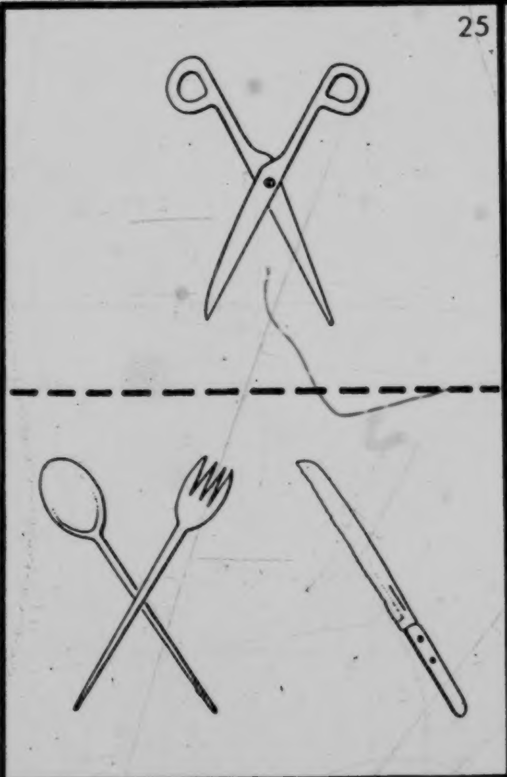

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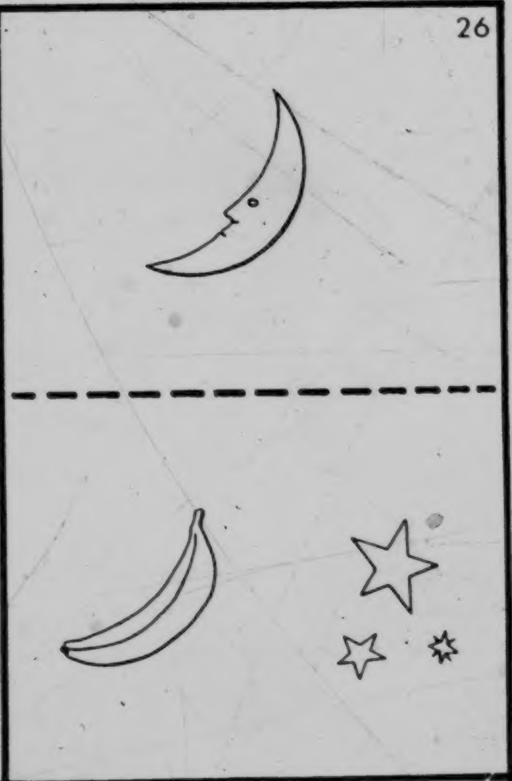

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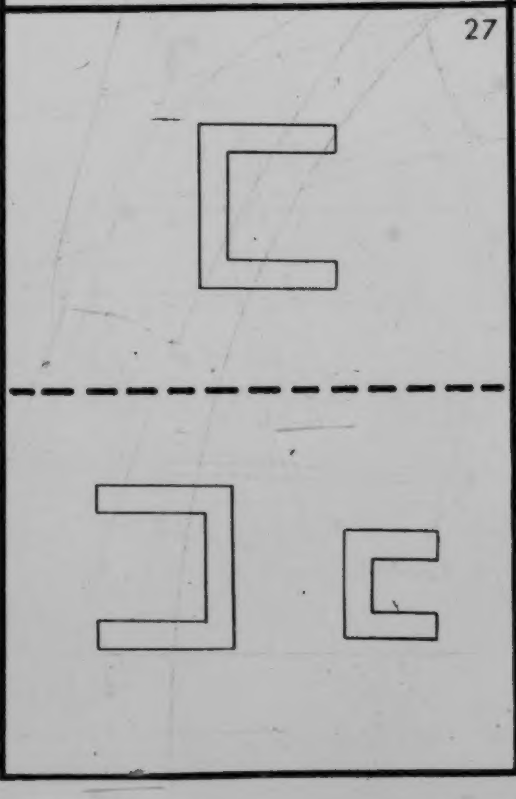

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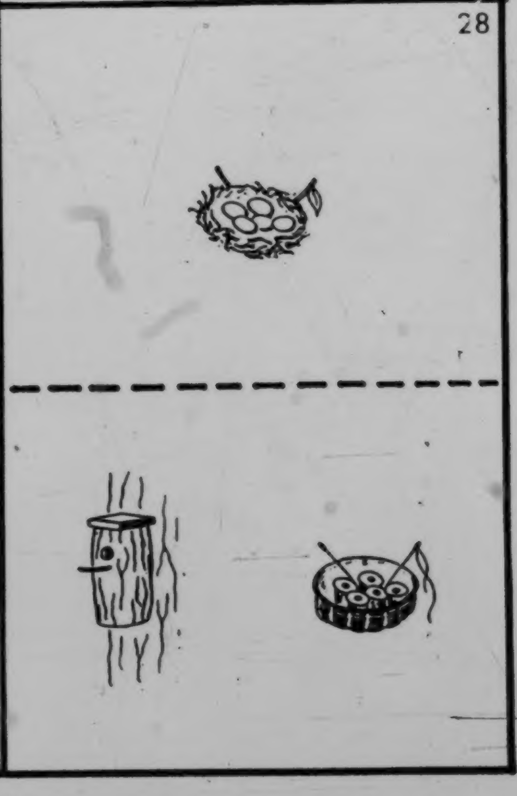

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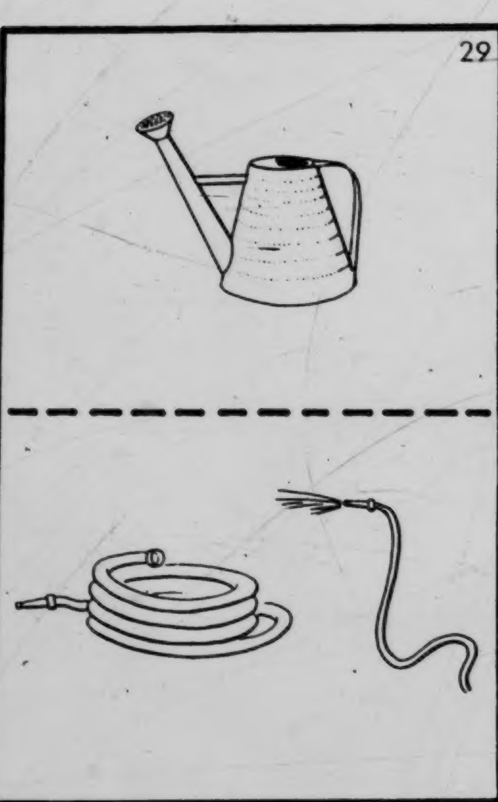

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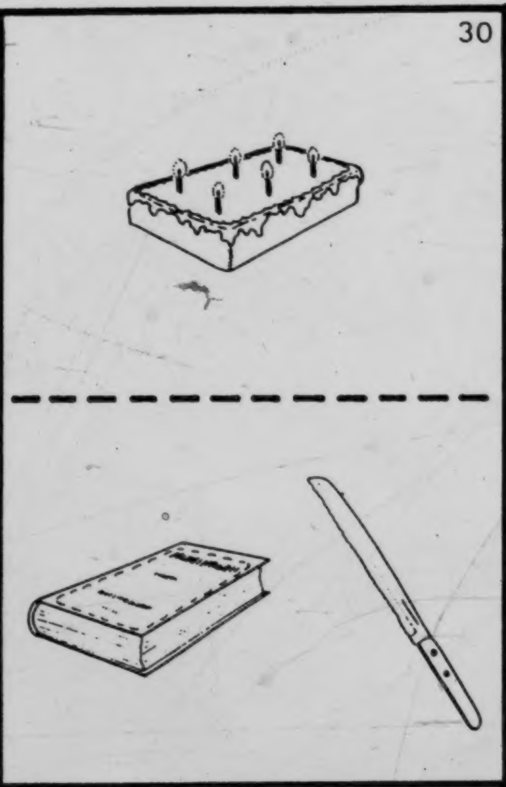

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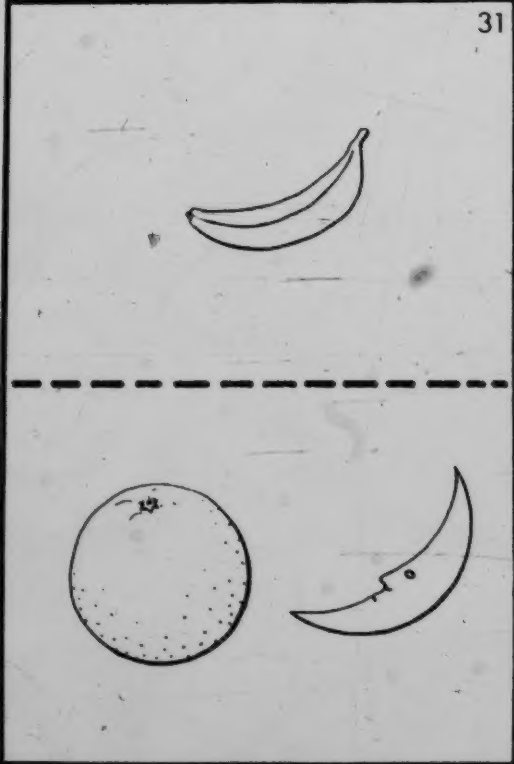

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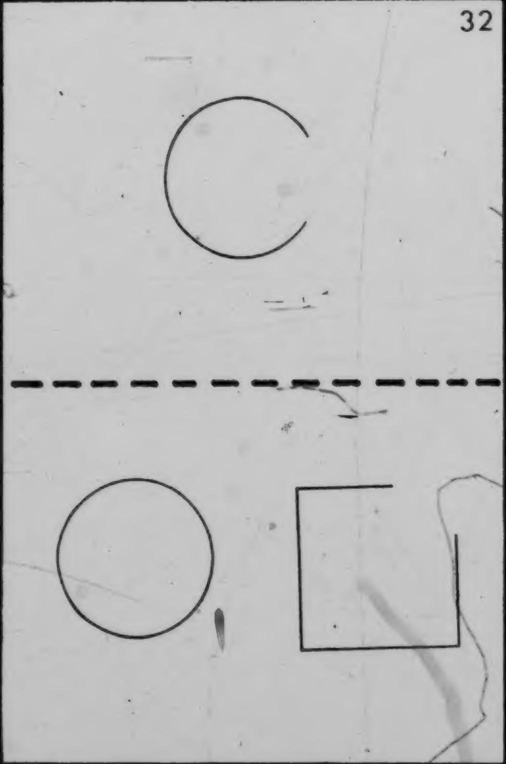

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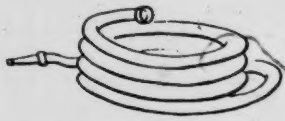

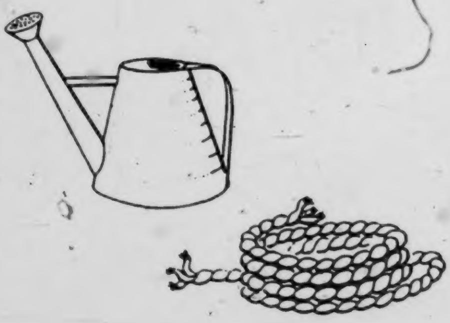

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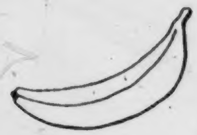

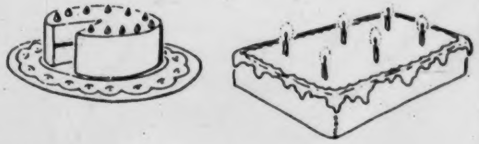

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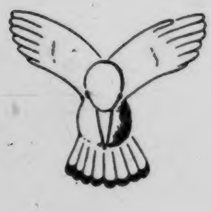

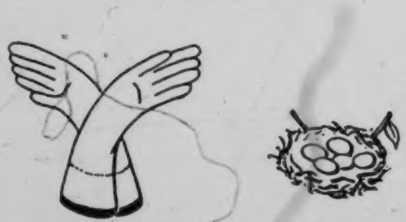

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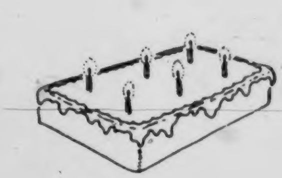

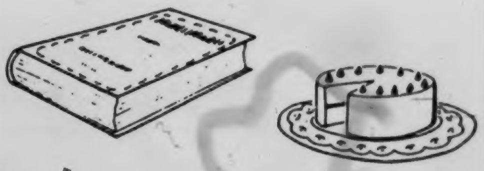

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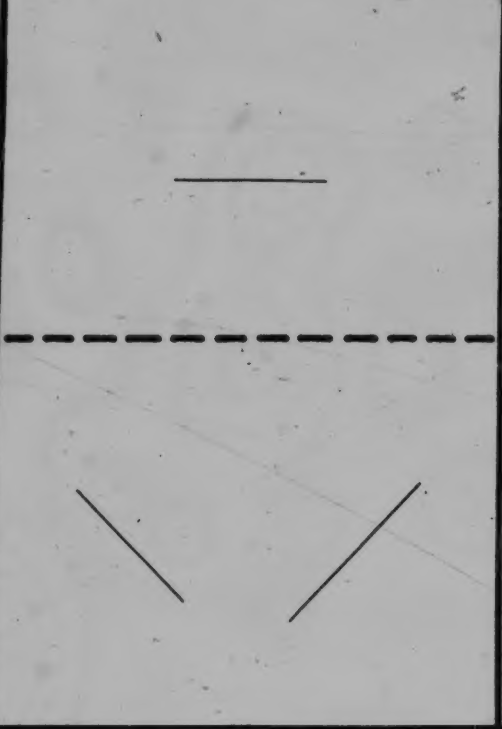

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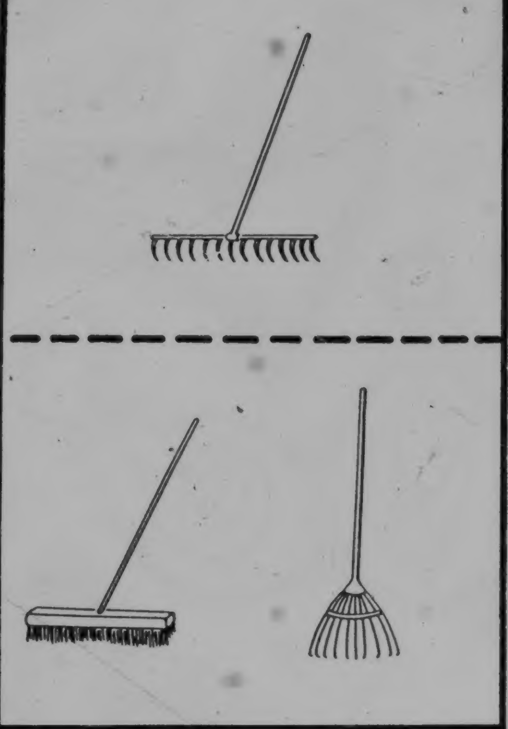

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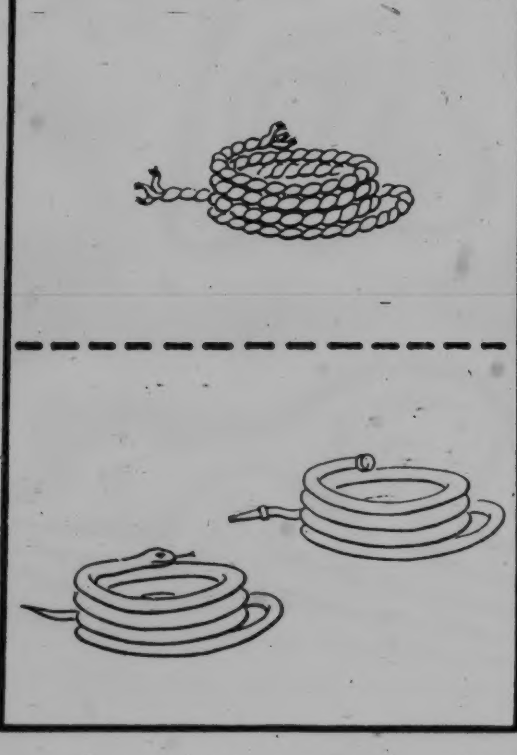

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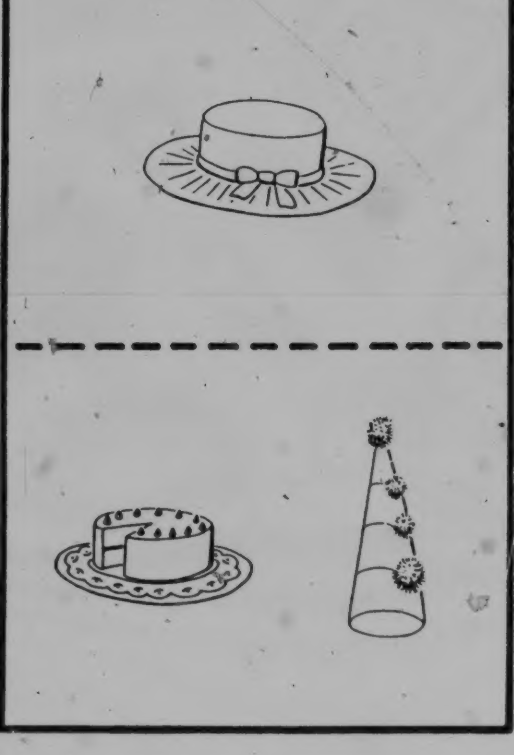


INSTRUCTIONS FOR THE TESTER

Sit facing the subject and say: THIS IS A **CHOOSING** GAME. I'M GOING TO SHOW YOU SEVERAL PICTURES. SOME OF THEM YOU WILL SEE 3 OR 4 TIMES, BUT YOU DON'T HAVE TO WORRY ABOUT THAT. YOU DON'T HAVE TO REMEMBER THEM. IN THIS GAME THERE ARE NO RIGHT OR WRONG ANSWERS. EACH TIME YOU ONLY NEED TO CHOOSE A PICTURE.

Show the first set of pictures. Point to the upper picture and say: LOOK CAREFULLY AT THIS PICTURE. Point to the two lower pictures: YOU CAN SEE THAT EACH OF THESE PICTURES BELONGS WITH THE UPPER ONE, BUT IN A DIFFERENT WAY. Point to the two dots and outline the two circles. I WANT YOU TO POINT TO THE PICTURE THAT SEEMS TO YOU TO GO BETTER WITH THE UPPER ONE. DO YOU UNDERSTAND THAT YOU CAN'T BE WRONG, BECAUSE THEY BOTH BELONG TO IT BUT IN DIFFERENT WAYS? Be sure that the subject understands.

NOW, I'M GOING TO SHOW YOU SOME MORE PICTURES AND, **EACH TIME**, THE PICTURES WILL GO TOGETHER BUT IN DIFFERENT WAYS. Show #2. POINT TO THE ONE THAT GOES BETTER WITH THE UPPER ONE. Continue showing the pictures at a rate that seems comfortable for the subject, repeating the instructions when necessary. If the person hesitates, say: DON'T THINK ABOUT IT TOO LONG. REMEMBER THAT YOU CAN'T MAKE A MISTAKE. Indicate both choices again. I ONLY WANT TO KNOW WHICH ONES YOU PREFER TO PUT TOGETHER. In every case be sure to get a choice.

For the items where the subject chooses more slowly, put an "x" in the Hesitation column but get a choice before continuing. Write any spontaneous remarks in the Comments column, but encourage the subject not to discuss or label the choices. To indicate the subject's choice each time, circle the number in the left column or the number in the right. Left and right correspond to your view of the pictures, not the view of the subject who should be sitting facing you.

When a choice has been made for #40, while still pointing to #40, say: NOW I WOULD LIKE YOU TO TELL ME ABOUT SOME OF THE PICTURES. WHAT WERE YOU THINKING WHEN YOU SAW THESE PICTURES? HOW DID YOU CHOOSE ONE TO GO WITH THIS ONE? Repeat with each item back to #34 writing a summary of the comments for each item on the back of the answer sheet. Then ask: DID YOU HAVE A KIND OF RULE FOR CHOOSING? IF SO, WHEN DID YOU START USING IT, AND WHAT WAS IT? Note the replies. Finally, with young children, show the sheets of single pictures and ask the subject to identify each one. Note only the ones not identified.

Please be sure to fill in all the demographic information. To determine handedness ask the subject to show you which hand they write with, brush their teeth with and throw a ball with. If inconsistent, call them ambidextrous.

ORDER OF ITEMS AND SCORING KEY

Table I-1: Scoring key and list of pictures

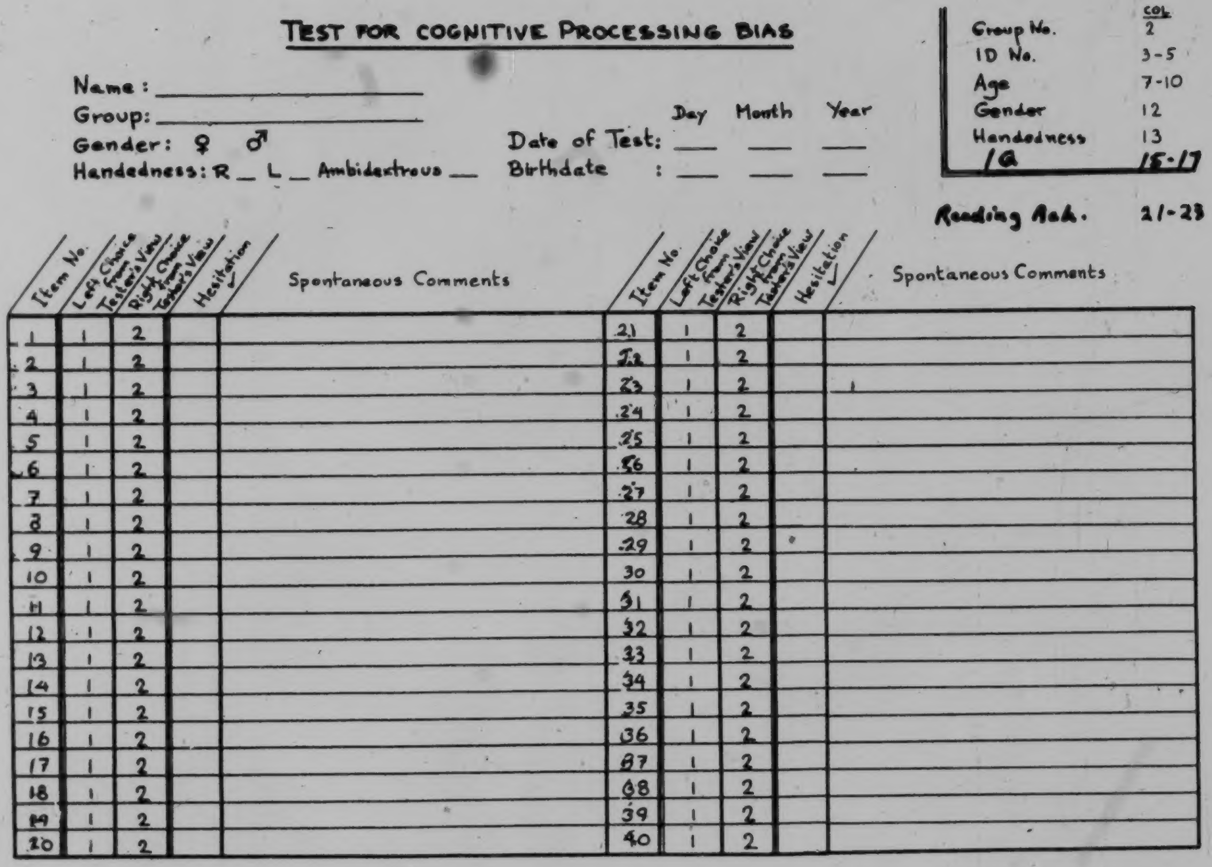
	KEY		PICTURES		
Order	Left for Tester	Right for Tester	Upper Picture	Left for Tester	Right for Tester
1					
2			orange	banana	banana
3			broom	girl	broom
4					
5	FORM	FUNCTION	bird	gloves	bird
6					
7	FUNCTION	FORM	snake	snake	rope
8					
9			nest	bird	bird
10			cake	cake	hat
11	FORM	FUNCTION	banana	moon	banana
12					
13	FUNCTION	FORM	book	book	cake
14	FORM	FUNCTION	nest	basket	bird
15			cake	banana	orange
16	FUNCTION	FORM	hose	hose	rope
17			gloves	hat	hat

...Continued

F-F Test Continued

Order	Left for Tester	Right for Tester	Upper Picture	Left for Tester	Right for Tester
18	FORM	FUNCTION	snake	rope	lizard
19					
20			cake	hat	knife
21			leaf	leaves	tree
22			broom	broom	rake
23	FUNCTION	FORM	orange	banana	ball
24					
25	FUNCTION	FORM	scissors	knife	fork&spoon
26	FORM	FUNCTION	moon	banana	stars
27					
28	FORM	FUNCTION	nest	basket	birdhouse
29			watering can	hose	hose
30	FUNCTION	FORM	cake	knife	book
31	FORM	FUNCTION	banana	moon	orange
32					
33	FORM	FUNCTION	hose	watering can	rope
34			banana	cake	cake
35	FUNCTION	FORM	bird	nest	gloves
36	FUNCTION	FORM	cake	cake	book
37					
38			rake	rake	broom
39			rope	hose	snake
40			hat	hat	cake

SAMPLE ANSWER SHEET



TEST FOR COGNITIVE PROCESSING BIAS

Name : ____________

Group: ____________

Gender: ♀ ♂

Handedness: R __ L __ Ambidextrous __

	Day	Month	Year
Date of Test:	___	___	___
Birthdate :	___	___	___

	col
Group No.	2
ID No.	3-5
Age	7-10
Gender	12
Handedness	13
IQ	15-17
Reading Ach.	21-23

Item No.	Left Choice from Tester's View	Right Choice from Tester's View	Hesitation ✓	Spontaneous Comments	Item No.	Left Choice from Tester's View	Right Choice from Tester's View	Hesitation ✓	Spontaneous Comments
1	1	2			21	1	2		
2	1	2			22	1	2		
3	1	2			23	1	2		
4	1	2			24	1	2		
5	1	2			25	1	2		
6	1	2			26	1	2		
7	1	2			27	1	2		
8	1	2			28	1	2		
9	1	2			29	1	2		
10	1	2			30	1	2		
11	1	2			31	1	2		
12	1	2			32	1	2		
13	1	2			33	1	2		
14	1	2			34	1	2		
15	1	2			35	1	2		
16	1	2			36	1	2		
17	1	2			37	1	2		
18	1	2			38	1	2		
19	1	2			39	1	2		
20	1	2			40	1	2		

SCORING

Since the Form and Function choices on the F-F Preference Test are compensatory (a choice of Form is a non-choice of Function), or ipsative (the sum of Form and Function choices always equals the total number of items), only one score need be calculated. Form choices on items were scored 2, Function choices 1, with 16 subtracted from the total to give F-F Preference Test scores ranging from 0 to 16. High scores, then, represent a Form Bias and low scores a Function Bias.

In order to investigate the factor strucure of the test, the Distractors were scored for a Right or Left choice but they were not considered in the actual scoring of the F-F Preference Test.

II. ADDITIONAL TABLES

Table II-1: Rotated factor matrix comparing Form/Function responses responses to F-F Test Items with Right/Left responses to Distractors

	FACTORS										
Item #	1	2	3	4	5	6	7	8	9	10	11
I#26	70	11	0	2	4	-23	4	8	-13	-14	7
I#31	53	20	4	10	38	- 5	8	1	-20	-14	8
I#23	36	18	- 4	2	51	4	9	25	-16	-18	10
I#25	69	4	1	-10	2	1	1	- 1	5	2	17
I#28	67	25	- 3	27	- 3	- 6	-12	- 7	8	-15	0
I#14	32	46	-11	48	- 9	4	- 5	-21	- 4	-18	3
I#35	62	9	7	- 5	17	- 5	-14	0	- 6	18	- 9
I# 5	19	54	0	-23	12	0	-26	-24	0	-11	-22
I#11	37	51	-10	19	8	-23	7	9	-17	3	- 4
I#13	27	59	-10	7	1	0	25	11	14	- 3	16
I#36	61	16	-18	22	14	6	5	- 7	17	10	-14
I#30	59	24	8	13	10	- 3	23	-11	12	7	-16
I#16	37	66	0	- 3	- 2	- 2	- 3	- 1	9	17	1
I# 7	23	66	3	- 8	- 5	1	-17	- 3	12	22	14
I#18	53	34	- 7	-17	- 4	16	-10	- 4	- 4	16	10
I#33	63	20	-19	- 6	- 8	3	- 9	14	- 3	- 1	- 6
D# 1	- 9	-25	46	32	2	11	-10	17	-20	- 1	13
D# 2	6	- 5	10	- 3	10	- 4	7	22	10	-68	- 2
D# 3	11	7	20	10	-17	-39	- 8	-38	22	2	-14
D# 4	2	8	5	- 1	18	4	- 3	1	- 3	11	82
D# 5	16	0	- 4	6	- 3	-34	-10	17	15	51	15
D# 6	4	2	0	12	- 6	-10	- 3	73	4	- 8	- 6
D# 7	- 3	0	- 4	- 2	4	0	0	- 3	73	- 2	- 3
D# 8	- 7	4	78	0	- 3	0	- 7	- 9	- 3	-17	6
D# 9	6	26	9	- 3	28	22	10	20	- 8	40	-44
D#10	0	48	- 4	15	16	2	8	16	-16	-16	-12
D#11	- 8	- 1	2	- 1	8	75	- 5	- 5	13	- 5	- 1
D#12	13	- 2	17	21	68	11	0	-27	14	1	15
D#13	36	- 9	23	-24	-16	29	-24	12	6	9	- 6
D#14	-13	4	1	0	-12	8	77	- 8	-13	- 9	2
D#15	6	- 9	5	- 9	28	-10	58	11	19	- 3	-11
D#16	- 3	- 7	80	- 8	13	2	15	2	11	6	- 7
D#17	18	- 2	27	22	-33	44	20	-12	-23	9	6
D#18	3	16	18	23	- 9	22	5	40	49	- 2	13
D#19	0	- 1	2	73	14	- 4	- 3	18	5	9	- 3

Table II-2: Frequency of Form choices on F-F Test Items (ordered by shape) at each level of Age, Balance & Reading

Age	5						6						7						9						11					
Rdng	Good			Poor			Good			Poor			Good			Poor			Good			Poor			Good			Poor		
#	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Circle																														
#23	7	8	6	9	4	7	9	9	9	8	8	7	7	8	4	8	9	7	7	8	4	5	3	8	3	5	6	3	7	8
Crescent																														
#31	6	8	4	9	4	6	8	7	9	6	8	7	7	8	4	9	8	7	6	5	5	4	3	8	3	2	4	4	6	6
#11	8	6	5	4	2	6	6	6	8	5	6	5	6	7	4	7	9	4	5	3	5	4	2	6	1	4	4	5	4	7
#26	7	4	2	5	5	4	9	7	9	6	5	7	5	6	3	6	9	7	6	6	4	4	3	6	3	2	1	3	1	8
Cube																														
#30	6	3	3	3	4	0	6	4	7	5	6	6	6	6	4	4	7	5	5	7	4	4	1	6	2	4	0	4	4	5
#13	5	9	2	6	2	1	5	6	4	4	3	3	5	5	2	5	4	3	4	1	3	4	1	2	0	2	3	4	3	4
Basket																														
#14	4	4	4	0	2	2	4	5	7	4	5	4	3	5	2	7	6	6	6	4	6	6	3	7	4	3	3	4	5	6
#28	6	4	3	1	1	1	9	5	8	5	5	3	5	6	4	6	7	7	5	5	6	4	3	6	0	2	2	4	4	6
Coil																														
# 7	1	1	2	2	1	1	5	7	2	4	3	3	5	5	2	4	7	4	6	2	5	4	3	6	5	3	4	5	6	8
#33	7	7	4	2	2	2	6	8	6	5	6	6	6	6	2	7	9	6	6	6	5	5	3	6	2	4	5	5	3	7
#16	3	2	1	3	1	0	5	7	5	4	4	2	5	6	4	4	5	7	6	5	3	4	3	6	4	3	4	4	3	7
#18	4	7	4	6	1	1	6	8	6	6	5	6	8	5	3	5	8	6	5	5	6	5	3	9	4	5	4	5	3	7
X																														
#25	5	7	4	3	3	3	9	9	8	8	9	6	8	5	3	7	7	7	6	6	4	3	2	6	4	3	5	3	3	7
Gloves																														
#35	6	7	3	4	2	5	8	8	6	6	5	4	6	7	5	5	6	5	4	7	5	5	3	7	3	5	4	4	4	4
# 5	3	3	2	3	1	2	6	5	6	4	2	2	4	5	3	6	6	5	5	3	3	4	1	7	4	2	6	1	3	6
n	8	9	8	10	5	7	9	9	9	9	9	7	8	9	5	9	9	7	7	8	6	6	6	9	9	9	9	7	9	9

Table II-3: Comparison of the factor patterns for various age groups with items ordered by functional association

Item	FACTORS IN EACH AGE GROUP																
	TOTAL GROUP			FIVES						MIDDLE					ELEVENS		
	1	2	3	1	2	3	4	5	6	1	2	3	4	5	1	2	3
Nominal																	
#11 Banana-Banana-Moon	24	19	72	65	13	-39	45	29	-34	24	17	18	94	-4	80	22	26
#16 Hose-Hose-Rope	25	73	17	38	10	17	7	20	70	7	67	27	11	18	57	37	25
# 7 Snake-Snake-Rope	12	63	21	15	-20	-11	-4	37	86	25	74	2	17	-2	44	27	36
# 5 Bird-Bird-Gloves	17	39	17	41	-5	-7	0	9	13	9	35	25	8	6	41	18	-9
#13 Book-Book-Cake	15	36	48	1	48	-6	12	15	44	8	37	16	43	7	61	22	48
#36 Cake-Cake-Book	47	26	29	51	16	5	9	0	6	33	14	64	5	12	45	17	44
Categorical																	
#25 Knife-Fork&Spoon-Sciss	62	22	0	5	-10	74	10	5	4	54	19	18	2	6	11	86	12
#26 Stars-Moon-Banana	66	9	24	12	95	7	-2	7	-5	73	7	20	8	11	31	70	19
#31 Orange-Moon-Banana	51	6	37	20	21	18	3	65	2	49	9	11	22	22	50	49	10
#28 Birdhouse-Nest-Basket	55	22	37	25	35	19	45	-26	8	46	12	48	17	4	48	37	42
#33 WateringCan-Hose-Rope	51	26	18	42	21	40	0	6	-10	41	29	21	12	-6	36	49	14
#18 Lizard-Snake-Rope	40	44	12	55	-17	33	3	-15	30	21	38	33	12	-8	28	48	34
#23 Banana-Orange-Ball	39	10	17	1	2	5	5	63	11	20	9	16	0	96	35	22	11
Relational																	
#14 Bird-Nest-Basket	24	27	44	4	-3	15	97	14	6	27	16	36	21	-2	67	2	15
#35 Nest-Bird-Gloves	49	26	12	48	5	18	2	11	7	21	27	42	8	17	8	50	40
#30 Knife-Cake-Book	43	32	27	5	33	55	13	18	6	8	25	48	31	18	11	21	97

Table II-4: Comparison of the factor patterns of F-F Test Items for Balance Groups ages 6 to 11 years

Item	FACTORS IN EACH GROUP												
	V-A			EQUAL					S-H				
	1	2	3	1	2	3	4	5	1	2	3	4	5
Nominal													
#11 Banana-Banana-Moon	14	46	88	30	72	17	10	11	25	27	4	15	88
#16 Hose-Hose-Rope	12	64	24	26	30	33	66	4	22	65	24	- 3	0
# 7 Snake-Snake-Rope	28	54	26	11	14	4	74	13	6	52	14	15	22
# 5 Bird-Bird-Gloves	37	19	15	30	23	- 8	35	13	- 4	68	-22	13	-10
#13 Book-Book-Cake	15	52	59	3	54	23	26	7	14	44	34	4	32
#36 Cake-Cake-Book	49	39	17	12	31	84	5	10	39	15	43	27	5
Categorical													
#25 Knife-Fork&Spoon-Scissors	69	15	4	63	10	29	9	20	60	8	37	17	11
#26 Stars-Moon-Banana	75	4	27	63	23	26	13	34	75	10	14	10	4
#31 Orange-Moon-Banana	37	11	61	32	10	6	12	93	64	6	12	23	26
#28 Birdhouse-Nest-Basket	66	26	41	25	38	55	23	30	40	1	18	51	9
#33 WateringCan-Hose-Rope	37	28	44	72	18	2	19	13	14	9	96	23	0
#18 Lisard-Snake-Rope	32	42	22	40	17	33	37	26	26	13	40	- 8	7
#23 Banana-Orange-Ball	49	28	26	10	15	11	9	45	55	27	6	9	-42
Relational													
#14 Bird-Nest-Basket	28	21	28	4	63	12	18	21	22	22	5	94	6
#35 Nest-Bird-Gloves	67	35	17	54	-14	47	25	11	24	34	15	1	13
#30 Knife-Cake-Book	28	83	19	31	36	43	4	9	39	28	11	14	10

Table II-5: Comparison of the factor patterns of Items+Age+Reading for Balance groups, ages 6 to 11

Association	FACTORS IN EACH GROUP														
Item	V-A				EQUAL					S-H					
	1	2	3	4	1	2	3	4	5	1	2	3	4	5	6
Nominal															
#11 Banana-Banana-Moon	43	53	6	71	66	37	18	-7	7	25	87	18	-10	3	5
#16 Hose-Hose-Rope	24	61	-5	13	43	20	61	28	2	1	27	-2	34	26	52
# 7 Snake-Snake-Rope	46	52	-16	7	15	4	76	10	11	-30	50	15	31	11	36
# 5 Bird-Bird-Gloves	42	14	13	2	12	31	40	2	10	-3	5	12	-2	-15	74
#13 Book-Book-Cake	32	55	10	47	57	13	25	-5	3	2	49	6	15	23	24
#36 Cake-Cake-Book	53	37	7	-4	71	-1	-4	48	15	39	10	29	15	45	14
Categorical															
#25 Knife-Fork&Spoon-Scissors	54	16	47	-19	22	62	6	37	17	25	28	22	52	21	-6
#26 Stars-Moon-Banana	73	9	24	-2	31	59	15	30	31	50	18	17	60	9	-1
#31 Orange-Banana-Moon	50	15	26	46	12	37	17	7	91	50	33	29	30	9	-2
#28 Birdhouse-Nest-Basket	68	30	29	14	63	13	20	34	33	29	13	54	16	18	-1
#33 WateringCan-Hose-Rope	50	33	6	24	13	63	26	22	10	3	9	22	19	95	-3
#18 Lizard-Snake-Rope	43	34	6	8	29	27	37	39	27	9	19	-7	32	37	2
#23 Banana-Orange-Ball	42	28	46	11	18	20	9	0	41	32	-24	14	50	7	32
Relational															
#14 Bird-Nest-Basket	47	19	-16	13	59	13	25	-17	18	9	13	96	10	8	20
#35 Nest-Bird-Gloves	63	36	22	-11	11	27	19	74	15	38	16	1	-12	23	42
#30 Knife-Cake-Book	20	95	23	-2	52	22	3	28	10	49	15	16	10	15	30
Age	-12	8	-97	-21	-12	-57	-6	-1	-17	-78	6	-8	-7	1	11
Reading	6	1	-2	-24	-5	5	4	29	-20	3	1	-5	-45	-9	-3

Table II-6: Comparison of the factor patterns of Items Only and Items + Age + Balance by Reading Groups, for ages 6 to 11

Item	ITEMS ONLY						ITEMS + AGE + BAL									
	Good			Poor			Good					Poor				
	1	2	3	1	2	3	1	2	3	4	5	1	2	3	4	5
Nominal																
#11 Banana-Banana-Moon	22	78	25	19	34	92	35	26	58	19	37	23	41	- 8	88	- 3
#16 Hose-Hose-Rope	27	17	67	22	75	14	20	65	24	10	- 4	70	13	11	25	- 2
# 7 Snake-Snake-Rope	8	18	60	20	67	20	4	50	33	16	-23	66	17	8	25	-22
#5 Bird-Bird-Gloves	13	11	33	31	35	13	8	39	2	15	3	44	24	6	11	1
#13 Book-Book-Cake	13	61	45	13	41	37	22	29	76	17	0	34	3	15	48	4
#36 Cake-Cake-Book	45	38	22	58	28	7	43	43	12	14	28	18	14	94	24	11
Categorical																
#25 Knife-Fork&Spoon-Sciss	69	11	19	61	16	11	69	20	9	3	-21	33	53	15	0	31
#26 Stars-Moon-Banana	83	17	18	62	9	28	82	28	0	17	-12	18	69	22	11	13
#31 Orange-Moon-Banana	59	36	14	49	11	35	64	19	24	8	9	22	55	4	20	15
#28 Birdhouse-Nest-Basket	60	65	- 5	62	39	7	70	11	30	21	34	46	39	40	7	3
#33 WateringCan-Hose-Rope	38	15	37	64	14	33	33	40	17	4	- 7	21	56	34	23	4
#18 Lizard-Snake-Rope	34	21	33	44	42	21	32	42	21	-15	5	49	39	13	17	4
#23 Banana-Orange-Ball	53	6	30	42	22	3	49	23	2	3	- 6	33	19	20	5	28
Relational																
#14 Bird-Nest-Basket	15	52	25	43	30	18	13	24	25	92	15	33	27	28	20	- 3
#35 Nest-Bird-Gloves	49	21	18	54	35	2	46	43	- 2	- 9	25	45	27	33	4	10
#30 Knife-Cake-Book	40	33	23	36	47	29	40	39	16	2	20	44	7	37	44	20
Age							-62	- 2	-21	4	- 3	13	-25	6	- 2	-95
Balance							- 4	- 4	2	4	35	6	16	26	- 7	-12

III. DESCRIPTION OF REPEATERS AND SPECIAL CLASS STUDENTS

Children who had repeated a grade or were in a special class could not be compared with their chronological age-mates on reading achievement because standardized reading tests are given in the schools by grade and not by age. The numbers in each group are recorded in Table III-1. It should be noted that children in the Stronger Verbal-Analytic Group rarely appeared in special classes, were frequently found among repeaters but less frequently appeared as Poor Readers in a regular class (none at all were found in Grade 6). Older children in the Stronger Spatial-Holistic Group were frequently found as Poor Readers in a normal class. In grade six, for instance, so many Poor Readers with stronger Spatial-Holistic skills were found in regular classes that there was no need to seek them in special classes. On the other hand, Good Readers with stronger Spatial-Holistic skills were extremely difficult to find among 7 and 9 year olds.

Table III-1: Numbers of repeaters or special class students among Poor Readers in each Cognitive Balance group

	Stronger S-H				Equal				Stronger V-A			
Age	Repeat		Special		Repeat		Special		Repeat		Special	
	n	%	n	%	n	%	n	%	n	%	n	%
6	1	14	1	14	1	11	0	0	2	18	0	0
7	4	57	1	14	2	22	0	0	2	22	2	22
9	3	27	4	36	5	83	0	0	3	50	0	0
11	3	27	0	0	3	27	0	0	7	100	0	0